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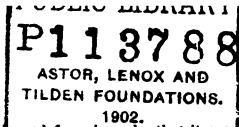


FIRE-STREAM TABLES

FOR USE OF

THE INSPECTORS OF THE ASSOCIATED FACTORY MUTUAL
INSURANCE COMPANIES.

Prepared by JOHN B. FREEMAN, Hydraulic Engineer,
March, 1882.



TO THE INSPECTORS :— This is prepared in a condensed form in order that it may be gummed into the back of Route Book. I had hoped to complete for circulation, along with the enclosed, some fairly complete notes on pumps, on friction loss in iron pipes, on the laying out of hydrant systems, etc.; but although a great deal of assistance in the work of computing and checking the enclosed tables has been given by Mr. Barr and Mr. Buttolph of this office, yet the laying out of the work and computation of the results of the experiments on hose and nozzles has occupied all spare time and most of my evenings for the past six months, and as the season of active field work has now arrived, the completion of further notes will have to be deferred until another winter.

FIRE-STREAM TABLES

FOR USE OF

THE INSPECTORS OF THE ASSOCIATED FACTORY MUTUAL
INSURANCE COMPANIES.

Prepared by JOHN R. FREEMAN, Hydraulic Engineer,
March, 1889.

The tables relating to fire streams in the various pump-makers' catalogues and various trade handbooks are all copied from the book called "Tables of Work Done by and Power Required for Fire Streams," by George A. Ellis. This book was based upon experiments made about eleven years ago by Mr. Ellis, at that time City Engineer of Springfield, Mass., assisted by Mr. A. P. Leshure, Chief of the Springfield Fire Department. I found that these tables gave unreasonable results when applied to the determination of the quantity a pump would deliver; and on looking into the matter further they were found to disagree with experiments made some years since by Mr. F. B. Weston, Assistant City Engineer of Providence. Therefore, toward the close of last season, I made quite a full series of experiments, with precautions to secure the highest degree of accuracy practicable, in order that we might have a sure foundation on which to base estimates. These experiments conclusively proved that the discharge as stated in Ellis's Tables, and their numerous copies in trade catalogues, is from 15 to 20 per cent. in error.

As the writer had the pleasure of exhibiting the apparatus and methods of the experiments to his fellow-inspectors and others on Oct. 13, 1888, at the Washington Mills, Lawrence, Mass., but little description is now needed. It may be mentioned, however, that a complete description will probably be published in the transactions of the American Society of Civil Engineers, or of the New England Water-Works Association, at an early day.

The following tables are based on these experiments, and I present them with entire confidence in their accuracy; but would remark that a table might be accurate for one kind of hose or nozzle and not give accurate results for hose or nozzles of different degrees of smoothness of finish. To remove such uncertainty, so far as nozzles were concerned, I experimented, in all, on about forty different nozzles, of various sizes, forms, and conditions of smoothness, and found that **any ordinary difference of form or finish of nozzle or play-pipe will not lead to error of any practical importance in use of tables, so long as size and kind (ring or smooth) is as given.** To determine how much the difference in smoothness of different kinds of hose or slight difference in its size would affect results, experiments were made on fourteen samples intended to represent the various kinds common in practical use. **In each table values are given for three different kinds of hose,** and as the two varieties of rubber hose are respectively the roughest and the smoothest, or the best and the poorest in conducting power, usually met in practice, **for other grades of hose intermediate values can be interpolated between those given in the table,** so there need be no errors of serious practical importance.

A word as to caution necessary when applying pressure gauges directly to the sprinkler system or inside of a check valve on mains. I was once puzzled for a while by finding pressure on a pipe system to be about 125 lbs., while the reservoir set at such a level as to call for only 100 lbs. at most. The explanation was simple: The extra pressure was due to water-ram caught and held by a check valve, acting like a ratchet and pawl. Partly opening the drain valve, of course quickly remedied the difficulty.

NOTES TABLES A, No. 1 to A, No. 9.

This is the most complete of the tables relating to fire streams, but is not in quite such convenient form for regular use in pump inspections as Table B, and does not show up the effect of a long line of hose or effect of inferior quality in reducing pressure so plainly as Table C.

This Table A is based throughout on accurate experiments, made under conditions similar to those of practical use. Nozzles of various sizes and styles were tested at pressures, at base of play-pipe, all the way from 5 lbs. to 105 lbs. This pressure at base of play-pipe was measured by an open mercury column, and was measured with certainty to a tenth of a pound, and the quantity discharged was measured in a tight rectangular tank. A careful study of all the experiments indicates that the number of gallons per minute discharged, given by Table A, as corresponding to a given indicated pressure at base of play-pipe, are correct within one-half of one per cent. for nozzles of almost any good, ordinary smooth form or finish. To measure the pressure very accurately at base of play-pipe, or within a line of hose, requires a special coupling, finished with much care, and with the small orifice leading to gauge exactly square and flush with inside surface; otherwise the accuracy of the gauge reading may suffer. Thus, for instance, if it were attempted to measure the pressure within a line of hose through which water enough for a good fire stream was flowing, by a piece of $\frac{1}{8}$ inch gas pipe, tapped into coupling and projecting $\frac{1}{4}$ inch inside, the pressure indicated might be as much as one or two pounds in error. Yet, for many purposes, this would be near enough.

Any special coupling for connecting gauge directly to hose or play-pipe itself is inconvenient to carry or to apply, and is especially inconvenient by reason of the unreasonable diversity of hose screw threads in different places. **When testing a hydrant system and measuring the number of gallons per minute that a pump can throw, the general experience is that the most convenient place for an inspector to measure the pressure is at the hydrant, as shown in Table B.** Nevertheless, the pressure at base of play-pipe is what throws the stream, and is the leading element in the study of fire streams; therefore this pressure at base of play-pipe is made the basis of Table A.

It will be noticed that I have called it *indicated* pressure; meaning by this that it was the pressure which a gauge attached to a $2\frac{1}{2}$ -inch coupling would *indicate* while stream was flowing. Most other authors base their tables on the static pressure, or the *indicated* pressure plus an allowance for velocity through the coupling; thus, for instance, my 50 pounds *indicated* pressure with the $1\frac{1}{8}$ -inch smooth nozzle corresponds to Ellis's or Weston's $51\frac{7}{10}$ pounds *effective* pressure. I adopted the *indicated* pressure as a basis for the tables because of the greater practical convenience in its measurement.

For cases in testing pumps where play-pipe is attached directly to hydrant without hose, discharge may be taken directly from Table A.

HEIGHT AND DISTANCE REACHED BY JETS.

Tables heretofore published have given, as the height of a jet corresponding to a given pressure, the extreme height to which the highest drops of water would rise in still air, and pumps have often been sold with representations based on such misleading data as to the height they would throw. Such data is almost worthless in considering fire protection, for the obvious reasons: first, that the water cannot be thrown in a direct vertical upon a building in flames; second, that, even if it could, the few scattering drops which would reach this height would be of no avail whatever in extinguishing the fire; third, that air still enough to permit these extreme drops to attain this height is not found more than one day in ten, and almost never during a fire. (Most of us have no idea how much influence the wind has upon the height that a jet of water can attain. While engaged on other work near at hand, I watched daily for almost six weeks to find a few hours when the air was still enough for accurate experiments, to determine the values for the second column of my table. Six or eight times I thought air was still enough, but, on getting experiments under way, would find that up at the top there was too much wind. I found that a merely moderate summer afternoon breeze would cut down height of extreme drops 10 or 15 per cent. Finally, there were found three brief periods when air was still.)

Therefore, I gave much attention to getting, for the different pressures, the extreme height at which stream was solid and forcible enough to constitute a good fire stream. It was hard to define this exactly within say 5 feet, and say just exactly where the stream ceased to be "good;" but I tried it under many different circumstances, and present the results as based on my best judgment. Some men would undoubtedly set the limit at 10 per cent. higher, but I took the effect of a moderate wind into account.

In defining the limit of a good effective fire stream for a given pressure, I have classed as *good* a stream which, at limit named, would enter through a window and barely strike ceiling with force to spatter well, and which at limit named had not lost continuity of stream by dividing into a shower of spray, and which at this limit appeared to shoot $\frac{1}{10}$ of the whole body of water inside a 15-inch circle, and $\frac{3}{4}$ of it within a 10-inch circle, nearly as I could judge by the eye.

With regard to the distance reached by jets, the same general remarks just given will also apply. The distance attained by the extreme drops measured as at a firemen's muster is misleading as practical information for fire protection; but that is the way the values in the ordinary tables are derived. A very faint breeze will increase or decrease the distance reached by the extreme drops by 10 per cent.

The columns of hydrant pressure which make up the main body of Table A are derived by adding to the nozzle or play-pipe pressure the friction loss in the hose, and also a smaller addition for the friction loss in the hydrant head; thus obtaining the hydrant pressure, measured as an inspector would ordinarily measure it.

This friction loss in hydrant was based upon experiments with a Chapman 4-way independent gate hydrant, but within the limits of practical use would probably not be more than a pound different for any other first-class hydrant.

The hose friction varies greatly in different kinds of hose, according to smoothness of inside surface or waterway. In most $2\frac{1}{2}$ -inch linen hose, although the bore of coupling is $2\frac{1}{2}$, the inside diameter of the hose under pressure is actually $2\frac{5}{8}$ inches, and table is therefore based on that size. The same is true for the best rubber-lined hose, while for the inferior rubber-lined the diameter of the hose is commonly $2\frac{1}{2}$ inches, and therefore was so taken in computing the table. As to the effect of slight changes in diameter of hose on friction loss, see Table C.

Photographs of plaster casts of the interior of three samples of the hose experimented upon are reproduced here; so that, if one wishes to do any very exact figuring, he can see the characteristics of surface to which the figures for the three grades mentioned in table apply with exactness.

Salesmen of inferior grades of hose often state with great positiveness (and equal disregard of fact and reason) that "roughness of surface makes no practical difference in flow," that "the water lies dead in the little hollows between the ridges and merely furnishes a cushion on which the main stream slides along," etc. Such notions were conclusively upset by the experiments of the eminent French engineer Darcy, over thirty years ago; and again proved untrue by the experiments men-

tioned above. The fact is that a rough surface apparently sets the whole stream all the way to its very centre into a condition of turmoil and eddying, and all these eddies absorb power. The same is true of iron pipes containing tubercles. An old tubercle-coated 6-inch pipe, in which there is a clear open waterway 5 inches diameter inside of projecting tubercles, may discharge no more water under a given pressure than would a smooth, clean pipe about 4 inches in diameter.

Unlined Linen Hose.

33.2 lbs. pressure lost by friction per 100 feet in length (or $2\frac{1}{4}$ times as much loss as in sample shown opposite.) This sample fairly represents all ordinary unlined linen hose,



PHOTOGRAPHS FROM PLASTER CASTS

Casts were all taken under a pressure of 50 lbs. per square inch. Photographs are half size of originals.

Losses of pressure given above views are those found by experiment for 240 minute (or a good $1\frac{1}{8}$ inch fire stream) flowing in hose exactly $2\frac{1}{2}$ inches in diameter out straight.

Inferior Rubber-Lined "Mill Hose,"

Woven Cotton Fabric.

(Average depth of corrugations, 15-1000 to 2-100 inch.)

25.5 lbs. pressure lost by friction per 100 feet in length of hose, or 80 per cent, more loss than in sample shown below,



(Rubber lining was rather thin, and cravices between threads next lining not being well filled, the water-pressure caused inner surface to conform to threads of fabric.)

Best Rubber-Lined Hose.

This sample was of woven cotton fabric.

(Average depth of corrugations, 1-1000 to 2-1000 inch.)

14.1 lbs. pressure lost by friction per 100 feet.

Rubber lining slightly thicker than in sample above, and interstices between threads next lining well filled with rubber, so inner surface remains smooth under pressure.



OF INTERIOR OF FIRE HOSE.

(In computing friction loss through hose for the tables, an allowance for increase of length by stretching, and also for effect of ordinary curves, was included; also, an allowance for excess of ordinary commercial diameter over nominal diameter.)

For the ordinary run of **leather hose** the values in column headed "Inferior Rubber-Lined" will apply fairly well. For **solid rubber hose** the columns headed "Ordinary Best Quality Rubber-Lined Hose" will apply. **These values all include allowance for the hose being laid as for ordinary use in rather crooked lines, and also include allowance for its stretch or elongation under pressure.**

An interesting feature of Table A is to take for instance Table A, No. 4, for $1\frac{1}{8}$ -inch smooth nozzle, follow across the page on the 40 lb. nozzle-pressure line.

Less than a 1 1-8-inch smooth-nozzle stream with ~~40~~⁴⁰ lbs. pressure at base of play-pipe, discharging about 240 gallons per minute, cannot be called a thoroughly first-class fire stream for a factory fire, although smaller and less powerful streams will answer well for fires in dwelling-houses, etc.

It will be seen from table (A, No. 4) that this smooth $1\frac{1}{8}$ -inch, 40 lb. stream will be a good effective stream up to the roof of a five-story mill. A hydrant pressure of 58 lbs. will give such a stream, if a line of linen hose only 50 feet long be used, as in the common run of pump tests. Now see what hydrant pressure would be needed if a line of linen hose of a not uncommon length for actual fire service, viz., 300 feet, were used. We see it would take a pressure at hydrant of 131 lbs. (and probably at least 140 or 150 lbs. at the fire pump, if pipes were of very ordinary size and crookedness). Similar results may be deduced by the tables for other sizes of nozzle, etc.; all of which show the great effect that length of hose has in reducing efficiency of a fire stream, and show that **if a mill manager or fireman expects to get a stream on to an actual fire through 200 to 500 feet of inferior hose, which will bear any resemblance to the stream he can get on dress parade through 50 feet of the same hose, he is liable some day to get sadly left.**

In a thoroughly well designed mill hydrant system it should be possible to concentrate full available delivery of pumps on any particular building of importance, by use of lines of hose not over 250 feet in length.

3/4-INCH SMOOTH

This Table may also be used to find the Pressure Required at Hydrant for any discharge, through any size nozzle, through any length of hose, and for any height of water column.

INDICATES				Pressure Required at Hydrant for any discharge, through any size nozzle, through any length of hose, and for any height of water column.			
Average at Highest Nozzle, Vertical Jet, 45 ft. High	Maximum Unit of Discharge, Good Flexible Fire Hose with Moderate Wind	Average Velocity, Discharge at Level of Nozzle, with only Air	Maximum Unit of Discharge, Good Flexible Fire Hose with Moderate Wind	Height per Minute Discharged	Length 50 ft.	Length 100 ft.	Length 200 ft.
5	17	37	37	37	5 5 5	6 6 5	6 6 6
10	17	52	52	52	11 11 10	12 11 11	13 13 12
15	25	64	64	64	16 16 16	17 17 16	19 19 17
20	33	73	73	73	22 22 21	23 23 22	26 25 23
25	41	82	82	82	27 27 26	29 28 27	32 31 28
30	48	90	90	90	33 32 31	35 34 32	39 38 34
35	55	97	97	97	38 38 37	40 40 38	45 44 40
40	60	104	104	104	43 43 42	46 46 43	52 50 46
45	64	110	110	110	49 48 47	52 51 48	58 57 51
50	67	116	116	116	54 54 52	58 57 54	65 63 57
55	70	122	122	122	60 59 58	64 63 59	71 69 63
60	72	127	127	127	65 65 63	69 68 65	78 76 68
65	74	132	132	132	71 70 68	75 74 70	84 82 74
70	76	137	137	137	76 75 73	81 80 75	91 88 80
75	78	142	142	142	81 81 79	87 85 81	97 94 85
80	79	147	147	147	87 86 84	93 91 86	104 101 91
85	80	151	151	151	92 92 89	98 97 92	110 107 97
90	81	156	156	156	98 97 94	104 102 97	117 113 102
95	82	160	160	160	103 102 99	110 108 102	123 120 108
100	83	164	164	164	109 108 105	116 114 108	130 126 114

80 pounds per square inch is now considered best hydrant pressure for general use 100 lbs. per sq. in. should not be exceeded, except occasionally for very high buildings, or lengths of hose exceeding 800 feet.

* If nozzle is much higher or lower than hydrant, allowance for difference of level must be made on hydrant pressure (10 feet in height corresponds to 4.33 lbs. water pressure).

NOZZLE. (This size of Nozzle gives too small a body of water for extinguishing a fire of much size.)

TABLE A.—No. 1.
(From experiments of
J. R. FREEMAN, 1888.)

ed for ⅜-inch Ring Nozzle.

—Height and Distance of Jet.

reamer) while stream is flowing, to maintain pressure at base of play-pipe, as per various lengths and kinds of 2½-inch Hose, as below.

Length 300 ft.			Length 400 ft.			Length 500 ft.			Length 600 ft.			Length 800 ft.			Length 1,000 ft.		
Unlined Linen Hose.			Unlined Linen Hose.			Unlined Linen Hose.			Unlined Linen Hose.			Unlined Linen Hose.			Unlined Linen Hose.		
lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
7	7	6	8	8	6	9	8	7	9	9	7	11	10	8	12	11	8
14	14	12	16	15	13	17	16	13	19	17	14	21	20	15	24	22	16
22	21	18	24	23	19	26	24	20	28	26	21	32	30	23	36	34	24
29	28	24	32	30	25	34	32	26	37	35	28	43	40	30	48	45	32
36	35	30	39	38	31	43	41	33	46	44	35	53	50	38	61	56	41
43	41	36	47	45	38	52	49	40	56	52	41	64	60	45	73	67	49
50	48	42	55	53	44	60	57	46	65	61	48	75	70	53	85	78	57
58	55	48	63	60	50	69	65	53	74	70	55	86	80	60	97	89	65
65	62	54	71	68	57	77	73	59	84	79	62	96	90	68	109	101	73
72	69	60	79	75	63	86	81	66	93	87	69	107	100	75	121	112	81
79	76	66	87	83	69	95	89	73	102	96	76	118	110	83	133	123	89
86	83	72	95	90	76	103	97	79	112	105	83	128	119	90	145	134	97
93	90	78	103	98	82	112	106	86	121	114	90	139	129	98	157	145	106
101	97	84	110	105	88	120	114	92	130	122	97	150	139	105	169	156	114
108	104	90	118	113	94	129	122	99	139	131	104	160	149	113	182	168	122
115	111	96	126	120	101	138	130	106	149	140	111	171	159	120	194	179	130
122	117	102	134	128	107	146	138	112	158	148	117	182	169	128	206	190	138
129	124	108	142	135	113	155	146	119	167	157	124	193	179	135	218	201	146
137	131	114	150	143	120	163	154	125	177	166	131	203	189	143	230	212	154
144	138	120	158	150	126	172	163	132	186	175	138	214	199	150	242	223	163

CAKE NOTICE.—The above is pressure at hydrant head *while stream is flowing*. The corresponding Static Reservoir Pressure, or Fire-pump Pressure, must be greater than hydrant pressure by an amount equal to friction loss between hydrant-head and pump or reservoir.

7/8-INCH SMOOTH

This Table may also be used for

Hydrant Pressure Required — Discharge

INDICATED PRESSURE		Extreme Height of Jet.		Extreme Horizontal Distance reached by Jet.		Gallons per Minute Discharged.	Pounds Pressure Required at Hydrant (first column, through)								
		Average of Highest Drops, Vertical Jet, Still Air.		Maximum Limit of Distance as Good Effective Fire Stream with Moderate Wind.			Length 50 ft.			Length 100 ft.			Length 200 ft.		
		lbs.	ft.	ft.	ft.		Unlined Linen Hose.	Inferior Rubber-lined Cotton "Mill Hose."—Inside Rough.	Ordinary best quality Rubber-lined Hose.—Inside Smooth.	Unlined Linen Hose.	Inferior Rubber-lined Cotton "Mill Hose."—Inside Rough.	Ordinary best quality Rubber-lined Hose.—Inside Smooth.	Unlined Linen Hose.	Inferior Rubber-lined Cotton "Mill Hose."—Inside Rough.	Ordinary best quality Rubber-lined Hose.—Inside Smooth.
Feeble Streams.	5.	11	18	18	21	50	6	6	5	6	6	6	8	7	
	10.	21	37	37	21	71	12	11	11	13	13	11	16	15	
	15.	31	56	56	27	87	17	17	16	19	19	17	23	22	
	20.	41	74	74	33	100	23	23	22	26	25	23	31	30	
Ordinary Fire Pressures.	25.	51	90	90	38	112	29	29	27	32	31	29	39	37	
	30.	61	103	103	42	123	35	34	33	39	38	34	47	45	
	35.	71	114	114	46	133	41	40	38	45	44	40	54	52	
	40.	81	124	124	49	142	46	46	43	52	50	46	62	59	
Unusually High Pressures.	45.	89	132	132	52	150	52	51	49	58	57	51	70	67	
	50.	97	140	140	55	159	58	57	54	65	63	57	78	74	
	55.	105	147	147	58	166	64	63	60	71	69	63	85	82	
	60.	112	153	153	61	174	70	69	65	78	75	69	93	89	
Unusually High Pressures.	65.	118	158	158	64	181	75	74	71	84	82	74	101	96	
	70.	123	163	163	66	188	81	80	76	90	88	80	109	104	
	75.	128	168	168	68	194	87	86	82	97	94	86	117	111	
	80.	132	172	172	70	201	93	91	87	103	101	91	124	119	
Unusually High Pressures.	85.	136	176	176	72	207	99	97	92	110	107	97	132	126	
	90.	139	180	180	74	213	104	103	98	116	113	103	140	134	
	95.	142	183	183	75	219	110	109	103	123	119	109	148	141	
	100.	144	186	186	76	224	116	114	109	129	126	114	155	148	

80 pounds per square inch is now considered best hydrant pressure for general buildings, or lengths of Hose exceeding 300 feet.

If nozzle is much higher or lower than hydrant, allowance for difference of level, be made on hydrant pressure (10 feet in height corresponds to 4.33 lbs. w pressure).

NOZZLE.

sed for 1-inch Ring Nozzle.

-Height and Distance of Jet.

TABLE A.—No. 2.

(From experiments of
J. R. FREEMAN, 1888.)

reamer) while stream is flowing, to maintain pressure at base of play-pipe, as per
arious lengths and kinds of 2½-inch Hose, as below.

Length 300 ft.			Length 400 ft.			Length 500 ft.			Length 600 ft.			Length 800 ft.			Length, 1000 ft.		
Unlined Linen Hose. Inferior Rubber-lined Cotton "Mill Hose."—Inside Rough. Ordinary best quality Rubber- lined Hose.—Inside Smooth.			Unlined Linen Hose. Inferior Rubber-lined Cotton "Mill Hose."—Inside Rough. Ordinary best quality Rubber- lined Hose.—Inside Smooth.			Unlined Linen Hose. Inferior Rubber-lined Cotton "Mill Hose."—Inside Rough. Ordinary best quality Rubber- lined Hose.—Inside Smooth.			Unlined Linen Hose. Inferior Rubber-lined Cotton "Mill Hose."—Inside Rough. Ordinary best quality Rubber- lined Hose.—Inside Smooth.			Unlined Linen Hose. Inferior Rubber-lined Cotton "Mill Hose."—Inside Rough. Ordinary best quality Rubber- lined Hose.—Inside Smooth.			Unlined Linen Hose. Inferior Rubber-lined Cotton "Mill Hose."—Inside Rough. Ordinary best quality Rubber- lined Hose.—Inside Smooth.		
lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
9	9	7	10	10	7	12	11	8	13	12	9	16	14	10	18	17	11
18	17	14	21	19	15	23	22	16	26	24	17	31	28	19	37	33	22
27	26	21	31	29	22	35	33	24	39	36	26	47	43	29	55	50	33
36	34	27	42	39	30	47	43	32	52	48	34	63	57	39	73	66	43
45	43	34	52	48	37	59	54	40	65	60	43	78	71	48	91	83	54
54	51	41	62	58	45	70	65	48	78	72	51	94	85	58	110	99	65
64	60	48	73	68	52	82	76	56	91	84	60	109	100	68	128	116	76
73	68	55	83	78	59	94	87	64	104	96	68	125	114	78	146	132	87
82	77	62	94	87	67	105	97	72	117	108	77	141	128	87	164	149	97
91	86	69	104	97	74	117	108	80	130	120	86	156	142	97	183	165	108
100	94	75	114	107	82	129	119	88	143	132	94	172	157	107	201	182	119
109	103	82	125	116	89	140	130	96	156	144	103	188	171	116	219	198	130
118	111	89	135	126	96	152	141	104	169	156	111	203	185	126	237	215	141
127	120	96	145	136	104	164	152	112	182	167	120	219	199	136	255	231	152
136	128	103	156	145	111	175	162	120	195	179	128	234	213	145	....	248	162
145	137	110	166	155	119	187	173	128	208	191	137	250	228	155	....	264	173
154	145	116	177	165	126	199	184	136	221	203	145	....	242	165	....	....	184
163	154	123	187	174	134	211	195	144	234	215	154	....	256	174	....	....	195
173	163	130	197	184	141	222	206	152	247	227	163	....	....	184	....	....	206
182	171	137	208	194	148	234	216	160	260	239	171	....	....	194	....	....	216

TAKE NOTICE.—The above is pressure at hydrant head *while stream is flowing*.
The corresponding Static Reservoir Pressure, or Fire-pump Pressure, must be
greater than hydrant pressure by an amount equal to friction loss between
hydrant-head and pump or reservoir.

-N.I.- SWCOTH

100-443887-100

No. of Cattle		No. of Horses		No. of Sheep		No. of Pigs		No. of Chickens		No. of Ducks		No. of Geese		No. of Rabbits		No. of Bees		No. of Fish		No. of Insects		No. of Plants		No. of Minerals		No. of Fossils		No. of Rocks		No. of Metals		No. of Gems		No. of Crystals		No. of Minerals		No. of Fossils		No. of Rocks		No. of Metals		No. of Gems		No. of Crystals																																																					
100	200	300	400	500	600	700	800	900	1000	1100	1200	1300	1400	1500	1600	1700	1800	1900	2000	2100	2200	2300	2400	2500	2600	2700	2800	2900	3000	3100	3200	3300	3400	3500	3600	3700	3800	3900	4000	4100	4200	4300	4400	4500	4600	4700	4800	4900	5000	5100	5200	5300	5400	5500	5600	5700	5800	5900	6000	6100	6200	6300	6400	6500	6600	6700	6800	6900	7000	7100	7200	7300	7400	7500	7600	7700	7800	7900	8000	8100	8200	8300	8400	8500	8600	8700	8800	8900	9000	9100	9200	9300	9400	9500	9600	9700	9800	9900	10000

4 1/2 pounds per square inch is now considered best hydrant pressure for general use
but the pressure should not be exceeded, except occasionally for very high
buildings, or lengths of hose exceeding 300 feet.

If nozzle is much higher or lower than hydrant, allowance for difference of level must be made in hydrant pressure: (1) foot in height corresponds to 4.33 lbs. water pressure.

NOZZLE.

—Height and Distance of Jet.

TABLE A.—No. 3.
(From experiments of)
J. R. FREEMAN, 1888.)

Steamer) while stream is flowing, to maintain pressure at base of play-pipe, as per various lengths and kinds of 2½-inch Hose, as below.

Length 300 ft.			Length 400 ft.			Length 500 ft.			Length 600 ft.			Length 800 ft.			Length 1000 ft.		
Unlined Linen Hose.			Unlined Linen Hose.			Unlined Linen Hose.			Unlined Linen Hose.			Unlined Linen Hose.			Unlined Linen Hose.		
Inferior Rubber-lined Cotton "Mill Hose."—Inside Rough.			Inferior Rubber-lined Cotton "Mill Hose."—Inside Rough.			Inferior Rubber-lined Cotton "Mill Hose."—Inside Rough.			Inferior Rubber-lined Cotton "Mill Hose."—Inside Rough.			Inferior Rubber-lined Cotton "Mill Hose."—Inside Rough.			Inferior Rubber-lined Cotton "Mill Hose."—Inside Rough.		
Ordinary best quality Rubber-lined Hose.—Inside Smooth.			Ordinary best quality Rubber-lined Hose.—Inside Smooth.			Ordinary best quality Rubber-lined Hose.—Inside Smooth.			Ordinary best quality Rubber-lined Hose.—Inside Smooth.			Ordinary best quality Rubber-lined Hose.—Inside Smooth.			Ordinary best quality Rubber-lined Hose.—Inside Smooth.		
lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
12	11	8	14	13	9	17	15	10	19	17	11	23	21	13	28	25	15
24	22	16	29	26	18	33	30	20	38	34	22	47	42	26	56	50	30
36	33	25	43	39	28	50	45	30	57	51	33	70	63	39	84	75	45
48	45	33	57	52	37	66	60	41	75	68	45	93	84	52	111	99	60
60	56	41	71	65	46	83	75	51	94	85	56	117	105	65	139	124	75
72	67	49	86	79	55	99	90	61	113	102	67	140	125	79	167	149	90
84	78	57	100	92	64	116	105	71	132	119	78	163	146	92	195	174	105
96	89	66	114	105	73	132	120	81	151	136	89	187	167	105	223	199	120
108	100	74	129	118	83	149	135	91	169	153	100	210	188	118	251	223	135
120	111	82	143	131	92	166	151	102	188	170	111	233	209	131	...	248	151
132	122	90	157	144	101	182	166	112	207	187	122	...	230	144	...	...	166
144	134	98	171	157	110	199	181	122	226	204	134	...	251	157	...	...	181
156	145	107	186	170	119	215	196	132	244	221	145	...	...	170	...	...	196
168	156	115	200	183	128	232	211	142	...	238	156	...	...	183	...	...	211
181	167	123	214	196	138	248	226	152	...	255	167	...	...	196	...	...	226
193	178	131	229	209	147	...	241	162	...	...	178	...	...	209	...	...	241
205	189	139	243	222	156	...	256	173	...	...	189	...	...	222	...	...	...
217	200	147	257	236	165	...	...	183	...	...	200	...	...	236	...	...	...
229	211	156	...	249	174	...	...	193	...	...	211	...	...	249	...	...	...
241	223	164	...	...	183	...	...	203	...	...	223	...	...	...	...	...	...

TAKE NOTICE. — The above is pressure at hydrant head *while stream is flowing*. The corresponding Static Reservoir Pressure, or Fire-pump Pressure, must be greater than hydrant pressure by an amount equal to friction loss between hydrant-head and pump or reservoir.

1 1/8-INCH SMOOTH Hydrant Pressure Required Discharge

INDICATED PRESSURE	Extreme Height of Jet.		Extreme Horizontal Distance reached by Jet.		Gallons per Minute Discharged.	Pounds Pressure Required at Hydrant first column, through											
	Average of Highest Drops, Vertical Jet, Still Air		Maximum Limit of Distance as Good Effective Fire Stream with Moderate Wind.			Length 50 ft.			Length 100 ft.			Length 200					
	ft.	ft.	ft.	ft.		Unlined Linen Hose.	Inferior Rubber-lined Cotton "Mill Hose."—Inside Rough.	Ordinary best quality Rubber- lined Hose.—Inside Smooth.	Unlined Linen Hose.	Inferior Rubber-lined Cotton "Mill Hose."—Inside Rough.	Ordinary best quality Rubber- lined Hose.—Inside Smooth.	Unlined Linen Hose.	Inferior Rubber-lined Cotton "Mill Hose."—Inside Rough.	Ordinary best quality Rubber- lined Hose.—Inside Smooth.			
by Gauge at- tached at Base of Play-Pipe, and set level with End of Nozzle.	ft.	ft.	ft.	ft.		lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.			
Feeble Streams,	5.	11	19	22	84	7	7	6	9	9	7	13	12				
	10.	22	39	22	119	15	14	12	18	17	14	26	24				
	15.	32	59	31	146	22	21	19	27	26	21	38	35				
	20.	43	80	38	168	29	28	25	36	34	28	51	47				
Ordinary Fire Streams, Fair. Good. Excellent.	25.	54	99	44	188	36	35	31	45	43	35	64	59				
	30.	64	115	50	206	44	42	37	55	52	42	77	71				
	35.	74	130	54	222	51	49	43	64	60	49	89	82				
	40.	84	142	59	238	58	56	50	73	69	56	102	94				
	45.	94	152	63	252	65	63	56	82	77	63	115	106				
	50.	104	162	66	266	72	70	62	91	86	70	128	118				
	55.	113	170	69	279	80	77	68	100	95	77	140	130				
	60.	122	178	72	291	87	84	74	109	103	84	153	141				
Unusually Strong Streams, (Difficult to hold Nozzle without special appliances.)	65.	130	185	75	303	94	91	81	118	112	91	166	153				
	70.	136	191	77	314	101	98	87	127	120	98	179	165				
	75.	142	197	79	325	109	105	93	136	129	105	191	177				
	80.	146	203	81	336	116	112	99	145	138	112	204	188				
	85.	150	209	83	346	123	119	106	154	146	119	217	200				
	90.	153	214	85	356	130	126	112	164	155	126	230	212				
	95.	156	219	87	366	138	133	118	173	163	133	242	224				
	100.	158	224	89	376	145	140	124	182	172	140	255	236				

80 pounds per square inch is now considered best hydrant pressure for general use. 100 lbs. per sq. in. should not be exceeded, except occasionally for very high buildings, or lengths of Hose exceeding 300 feet.

If nozzle is much higher or lower than hydrant, allowance for difference of level must be made on hydrant pressure (10 feet in height corresponds to 4.33 lbs. per square inch pressure).

NOZZLE. (This is the size preferred for general outside use.)

—Height and Distance of Jet.

TABLE A.—No. 4.
(From experiments of
J. R. FREEMAN, 1898.)

Steamer) while stream is flowing, to maintain pressure at base of play-pipe, as per various lengths and kinds of 2½-inch Hose, as below.

Length 300 ft.			Length 400 ft.			Length 500 ft.			Length 600 ft.			Length 800 ft.			Length 1000 ft.		
Unlined Linen Hose.			Unlined Linen Hose.			Unlined Linen Hose.			Unlined Linen Hose.			Unlined Linen Hose.			Unlined Linen Hose.		
Inferior Rubber-lined Cotton "Mill Hose,"—Inside Rough.			Inferior Rubber-lined Cotton "Mill Hose,"—Inside Rough.			Inferior Rubber-lined Cotton "Mill Hose,"—Inside Rough.			Inferior Rubber-lined Cotton "Mill Hose,"—Inside Rough.			Inferior Rubber-lined Cotton "Mill Hose,"—Inside Rough.			Inferior Rubber-lined Cotton "Mill Hose,"—Inside Rough.		
Ordinary best quality Rubber-lined Hose.—Inside Smooth.			Ordinary best quality Rubber-lined Hose.—Inside Smooth.			Ordinary best quality Rubber-lined Hose.—Inside Smooth.			Ordinary best quality Rubber-lined Hose.—Inside Smooth.			Ordinary best quality Rubber-lined Hose.—Inside Smooth.			Ordinary best quality Rubber-lined Hose.—Inside Smooth.		
lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
16	15	10	20	18	12	24	21	13	28	25	15	35	31	18	42	37	21
33	30	20	40	36	24	48	43	27	55	49	30	70	62	36	84	75	43
49	45	31	60	54	35	71	64	40	82	74	45	105	93	54	127	112	64
66	60	41	80	73	47	95	85	54	110	98	60	139	123	73	168	149	85
82	75	51	101	91	59	119	107	67	137	123	75	174	154	91	211	186	107
99	90	61	121	109	71	143	128	80	165	147	90	209	185	109	253	223	128
115	105	71	141	127	82	166	149	94	192	172	105	243	216	127	....	261	149
131	120	81	161	145	94	190	171	107	220	196	120	278	247	145	....	....	171
148	135	92	181	163	106	214	192	120	247	221	135	....	278	163	....	....	192
164	150	102	201	181	118	238	213	134	274	245	150	....	....	181	....	....	213
181	165	112	221	200	130	262	235	147	....	270	165	....	....	200	....	....	235
197	180	122	241	218	141	....	256	160	....	....	180	....	....	218	....	....	256
214	195	132	261	236	153	....	....	174	....	....	195	....	....	236	....	....	....
230	209	143	....	254	165	....	....	187	....	....	209	....	....	254	....	....	....
246	224	153	....	....	177	....	....	201	....	....	224	....	....	....	....	....	....
263	239	163	....	....	188	....	....	214	....	....	239	....	....	....	....	....	....
....	254	173	....	....	200	....	....	227	....	....	254	....	....	....	....	....	....
....	....	183	....	....	212	....	....	241	....	....	....	....	....	....	....	....	....
....	....	194	....	....	224	....	....	254	....	....	....	....	....	....	....	....	....
....	....	204	....	....	236	....	....	....	....	....	....	....	....	....	....	....	....

TAKE NOTICE.—The above is pressure at hydrant head *while stream is flowing*. The corresponding Static Reservoir Pressure, or Fire-pump Pressure, must be greater than hydrant pressure by an amount equal to friction loss between hydrant-head and pump or reservoir.

1 1/4-INCH SMOOTH Hydrant Pressure Required — Discharge

INDICATED PRESSURE		Extreme Height of Jet.		Extreme Horizontal Distance reached by Jet.		Gallons per Minute Discharged.	Pounds Pressure Required at Hydrant (first column, through)								
		Average of Highest Drops, Vertical Jet, Still Air.		Maximum Limit of Height as Good Effective Fire Stream with Moderate Wind.			Length 50 ft.			Length 100 ft.			Length 200		
		ft.	ft.	ft.	ft.		Unlined Linen Hose.	Interior Rubber-lined Cotton "Mill Hose."—Inside Rough.	Ordinary best quality Rubber- lined Hose.—Inside Smooth.	Unlined Linen Hose.	Interior Rubber-lined Cotton "Mill Hose."—Inside Rough.	Ordinary best quality Rubber- lined Hose.—Inside Smooth.	Unlined Linen Hose.	Interior Rubber-lined Cotton "Mill Hose."—Inside Rough.	Ordinary best quality Rubber.
Feeble Streams.	lbs.	ft.	ft.	ft.	ft.		lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
	5.	11	....	19	....	105	8	8	7	11	11	8	17	15	
	10.	22	cent. higher.	40	22	148	17	16	14	23	21	16	34	31	
	15.	33		62	32	181	25	24	21	34	32	24	51	47	
	20.	44		83	40	209	34	32	27	45	42	32	68	62	
Ordinary Fire Streams.	lbs.	ft.	ft.	ft.	ft.		lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
	25.	55	is about 10 per	103	47	234	42	40	34	57	53	40	85	77	
	30.	66	cent. higher.	119	54	256	51	49	41	68	63	49	102	93	
	35.	76		134	59	277	59	57	48	79	74	57	119	109	
	40.	86	is about 12 per	148	63	296	68	65	55	91	84	65	136	124	
Unusually Strong Streams. (Difficult to hold Nozzle without special appliances.)	lbs.	ft.	ft.	ft.	ft.		lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
	45.	97	fire stream "	159	67	314	76	73	62	102	95	73	153	140	
	50.	107		169	70	331	85	81	68	113	106	81	170	155	
	55.	117	fire stream "	178	73	347	93	89	75	124	116	89	187	170	
	60.	126	fire stream "	186	76	363	102	97	82	136	127	97	204	186	
Excellent.	lbs.	ft.	ft.	ft.	ft.		lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
	65.	133	is about 10 per	193	79	377	110	105	89	147	137	105	221	201	
	70.	140	cent. higher.	200	81	392	118	113	96	158	148	113	238	217	
	75.	145		207	83	405	127	121	103	170	158	121	255	232	
	80.	150	limit as a "fair	213	85	419	135	129	110	181	169	129	....	248	
Maximum	lbs.	ft.	ft.	ft.	ft.		lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
	85.	154	fire stream "	219	88	432	144	137	116	192	179	137	....	263	
	90.	157	limit as a "fair	225	90	444	152	145	123	204	190	145	....	....	
	95.	159	cent. higher.	231	92	456	161	154	130	215	201	154	....	....	
	100.	161	fire stream "	236	93	468	169	162	137	226	211	162	....	....	

80 pounds per square inch is now considered best hydrant pressure for general use. 100 lbs. per sq. in. should not be exceeded, except occasionally for very high buildings, or lengths of Hose exceeding 300 feet.

If nozzle is much higher or lower than hydrant, allowance for difference of level must be made on hydrant pressure (10 feet in height corresponds to 4.33 lbs. water pressure).

HOZZLE. (This size is well adapted for serious fires where water supply is ample and line of hose not too long.) **TABLE A.—No. 5.**
 Height and Distance of Jet. (From experiments of J. R. FREEMAN, 1888.)

amer) while stream is flowing, to maintain pressure at base of play-pipe, as per
 rious lengths and kinds of 2½-inch Hose, as below.

Length 300 ft.			Length 400 ft.			Length 500 ft.			Length 600 ft.			Length 800 ft.			Length 1000 ft.		
Inferior Rubber-lined Cotton "Mill Hose,"—Inside Rough.	Ordinary best quality Rubber-lined Hose.—Inside Smooth.	Unlined Linen Hose.	Inferior Rubber-lined Cotton "Mill Hose,"—Inside Rough.	Ordinary best quality Rubber-lined Hose.—Inside Smooth.	Unlined Linen Hose.	Inferior Rubber-lined Cotton "Mill Hose,"—Inside Rough.	Ordinary best quality Rubber-lined Hose.—Inside Smooth.	Unlined Linen Hose.	Inferior Rubber-lined Cotton "Mill Hose,"—Inside Rough.	Ordinary best quality Rubber-lined Hose.—Inside Smooth.	Unlined Linen Hose.	Inferior Rubber-lined Cotton "Mill Hose,"—Inside Rough.	Ordinary best quality Rubber-lined Hose.—Inside Smooth.	Unlined Linen Hose.	Inferior Rubber-lined Cotton "Mill Hose,"—Inside Rough.	Ordinary best quality Rubber-lined Hose.—Inside Smooth.	Unlined Linen Hose.
lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
3 20 13	28 25 15	34 30 18	40 35 20	51 45 25	63 55 30	6 41 26	57 51 31	68 61 36	80 71 41	103 90 51	125 110 61	8 61 39	85 76 47	102 91 54	120 106 61	154 136 76	188 165 91
1 82 52	114 102 62	137 121 72	159 141 82	205 181 101	251 220 121	4 102 65	142 127 77	171 152 90	199 176 102	256 226 127	 275 152	6 123 78	171 152 93	205 182 108	239 212 123	 271 152	 275 152
9 143 91	199 178 109	239 212 126	279 247 142	 283 164	 203 124	273 243 144	 273 162	 204 180	 225 198	 245 216	 266 169	 254 155	 170	 216	 234	 252	 232
2 164 104	227 203 124	273 243 144	 283 164	 203 124	 201	 217	 232	 248	 221	 234	 247	 261	 221	 234	 247	 261	 221
5 184 117	256 229 140	 273 162	 204 180	 225 198	 245 216	 266 169	 254 155	 170	 216	 234	 252	 232	 248	 221	 234	 247	 261
7 204 130	 254 155	 180	 204 180	 225 198	 245 216	 182	 217	 232	 248	 221	 234	 247	 261	 221	 234	 247	 261
9 225 143	 170	 216	 234	 252	 232	 248	 221	 234	 247	 261	 221	 234	 247	 261	 221	 234	 247
245 156	 186	 216	 234	 252	 232	 248	 221	 234	 247	 261	 221	 234	 247	 261	 221	 234	 247
266 169	 201	 234	 252	 232	 248	 221	 234	 247	 261	 221	 234	 247	 261	 221	 234	 247	 261
.... 182	 217	 232	 248	 221	 234	 247	 261	 221	 234	 247	 261	 221	 234	 247	 261	 221	 234
.... 195	 232	 248	 221	 234	 247	 261	 221	 234	 247	 261	 221	 234	 247	 261	 221	 234	 247
.... 208	 248	 221	 234	 247	 261	 221	 234	 247	 261	 221	 234	 247	 261	 221	 234	 247	 261
.... 221	 261	 221	 234	 247	 261	 221	 234	 247	 261	 221	 234	 247	 261	 221	 234	 247	 261
.... 234	 261	 221	 234	 247	 261	 221	 234	 247	 261	 221	 234	 247	 261	 221	 234	 247	 261
.... 247	 261	 221	 234	 247	 261	 221	 234	 247	 261	 221	 234	 247	 261	 221	 234	 247	 261
.... 261	 261	 221	 234	 247	 261	 221	 234	 247	 261	 221	 234	 247	 261	 221	 234	 247	 261

KEY NOTICE. — The above is pressure at hydrant head *while stream is flowing*. The corresponding Static Reservoir Pressure, or Fire-pump Pressure, must be greater than hydrant pressure by an amount equal to friction loss between hydrant-head and pump or reservoir.

1 3/8-INCH SMOOTH Hydrant Pressure Required — Discharge

INDICATED PRESSURE		Extreme Height of Jet.		Extreme Horizontal Distance reached by Jet.		Gallons per Minute Discharged.	Pounds Pressure Required at Hydrant (first column, through)								
		Average of Highest Drops, Vertical Jet, Still Air.	Maximum Limit of Height as Good Effective Fire Stream with Moderate Wind.	Average of Highest Drops at level of Nozzle, with Still Air.	Maximum Limit of Distance as Good Effective Fire Stream with Moderate Wind.		Length 50 ft.			Length 100 ft.			Length 200 ft.		
by Gauge at- tached at Base of Play-Pipe, and set level with End of Nozzle.		lbs.	ft.	ft.	ft.		Unlined Linen Hose.	Inferior Rubber-lined Cotton "Mill Hose."—Inside Rough.	Ordinary best quality Rubber- lined Hose.—Inside Smooth.	Unlined Linen Hose.	Inferior Rubber-lined Cotton "Mill Hose."—Inside Rough.	Ordinary best quality Rubber- lined Hose.—Inside Smooth.	Unlined Linen Hose.	Inferior Rubber-lined Cotton "Mill Hose."—Inside Rough.	Ordinary best quality Rubber- lined Hose.—Inside Smooth.
Feeble Streams.		5.	12	19	23	128	10	10	8	15	13	10	23	21	17
		10.	23	41	23	182	20	19	16	29	27	19	46	42	29
		15.	34	63	33	222	31	29	23	44	40	29	69	62	41
		20.	45	85	42	257	41	39	31	58	53	39	92	83	55
Ordinary Fire Streams. Good. Fair.		25.	56	106	49	287	51	48	39	73	67	48	115	104	66
		30.	67	123	56	316	61	58	47	87	80	58	139	125	80
		35.	78	138	62	340	71	67	54	102	94	67	162	146	90
		40.	89	152	66	363	82	77	62	116	107	77	185	166	100
Excellent.		45.	100	164	70	385	92	87	70	131	120	87	208	187	120
		50.	111	175	73	406	102	96	78	145	134	96	231	208	130
		55.	121	184	76	426	112	106	86	160	147	106	254	229	140
		60.	131	192	79	445	122	116	93	174	160	116	280	250	160
Unusually Strong Streams. (Difficult to hold Nozzle without special appliances.)		65.	138	200	82	463	133	125	101	189	174	125	300	270	170
		70.	144	207	84	480	143	135	109	203	187	135	320	285	180
		75.	149	214	86	497	153	145	117	218	200	145	340	300	190
		80.	154	220	88	514	163	154	124	232	214	154	360	315	200
Maximum		85.	158	226	90	529	174	164	132	247	227	164	380	330	210
		90.	161	232	92	545	184	173	140	261	240	173	400	345	220
		95.	163	238	94	560	194	183	148	275	254	183	420	360	230
		100.	165	243	96	574	204	193	156	289	267	193	440	375	240

80 pounds per square inch is now considered best hydrant pressure for general use. 100 lbs. per sq. in. should not be exceeded, except occasionally for very high buildings, or lengths of Hose exceeding 300 feet.

If nozzle is much higher or lower than hydrant, allowance for difference of level must be made on hydrant pressure (10 feet in height corresponds to 4.33 lbs. water pressure).

BLE.

ht and Distance of Jet.

TABLE A.—No. 6.
(From experiments of
J. R. FREEMAN, 1888.)

while stream is flowing, to maintain pressure at base of play-pipe, as per
lengths and kinds of 2½-inch Hose, as below.

ft.	Length 400 ft.			Length 500 ft.			Length 600 ft.			Length 800 ft.			Length 1,000 ft.		
Ordinary best quality Rubber-lined Hose.—Inside Smooth.	Unlined Linen Hose.	Inferior Rubber-lined Cotton "Mill Hose."—Inside Rough.	Ordinary best quality Rubber-lined Hose.—Inside Smooth.	Unlined Linen Hose.	Inferior Rubber-lined Cotton "Mill Hose."—Inside Rough.	Ordinary best quality Rubber-lined Hose.—Inside Smooth.	Unlined Linen Hose.	Inferior Rubber-lined Cotton "Mill Hose."—Inside Rough.	Ordinary best quality Rubber-lined Hose.—Inside Smooth.	Unlined Linen Hose.	Inferior Rubber-lined Cotton "Mill Hose."—Inside Rough.	Ordinary best quality Rubber-lined Hose.—Inside Smooth.	Unlined Linen Hose.	Inferior Rubber-lined Cotton "Mill Hose."—Inside Rough.	Ordinary best quality Rubber-lined Hose.—Inside Smooth.
lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
17	40	36	21	49	43	25	57	51	28	74	66	36	92	80	43
34	81	71	42	98	86	49	115	101	56	149	131	71	184	161	86
51	121	107	62	147	129	74	172	152	85	224	196	107	275	241	129
68	161	143	83	195	173	98	230	202	113	299	262	143	....	321	173
85	201	178	104	244	216	123	287	253	141	....	....	178	....	....	216
103	242	214	125	293	259	147	....	....	169	....	....	244	....	....	259
120	282	250	146	....	....	172	....	....	198	....	....	250	....	....	....
137	....	....	166	....	....	196	....	....	226	....	....	....	....	....	....
154	....	....	187	....	....	221	....	....	254	....	....	....	....	....	....
171	....	....	208	....	....	245	....	....	....	....	....	....	....	....	....
188	....	....	229	....	....	270	....	....	....	....	....	....	....	....	....
205	....	....	250	....	....	....	....	....	....	....	....	....	....	....	....
222	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
239	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
256	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
....															
....															
....															
....															

NOTICE. — The above is pressure at hydrant head *while stream is flowing*.
; corresponding Static Reservoir Pressure, or Fire-pump Pressure, must be
ater than hydrant pressure by an amount equal to friction loss between
rdrant-head and pump or reservoir.



Experiments on Fire Streams at High Elevations.

The final experiments on which tables for height of jets are based were made at this site these only one nozzle was used at a time.

Sketch illustrates experiments to determine which of two nozzles (ring or smooth, for it was the better, or would throw stream highest and with the least spraying, — pressure at each play-pipe being the same. For this the two 50-ft. lines of hose leading to play-pipes same kind; bends in hose at base of play-pipe were carefully laid flat on the inclined platform shown, and clamped between blocks jig-sawed from 3-in. plank, so each hose lay in flat 3 feet radius. 1 to 2 feet of hose next base of play-pipe was straight.

The masts, A and B, were graduated in feet, and reached to a height of 124 feet above the roof. Below the masts, scales, made of strips of wood strung on heavy steel wire, marked each height along face of wall.

Horizontal distances from end of nozzle were marked by wooden rods 10 feet apart, to top of wall, as shown.

When height of jet was more than 130 feet, the mast, C, and sighting bar, D, were used for estimating height, proper allowance being made for parallax.

The play-pipes and their supporting platform could be set at any angle of elevation and were securely clamped.

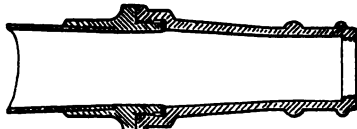
End of nozzle was set level with zero of mercury pressure gauges and zero of scale of

An assistant regulated pressure to within one-tenth of a pound by valves at hydrant, as all was ready, one observer read the mercury gauges each half minute, while another observed height and characteristics of jet, as seen from the mill roots.

Smooth Nozzle Standard Form.

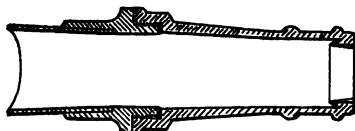


Ordinary Square Ring Nozzle.



Diameter of Stream about $\frac{1}{8}$ inch smaller than orifice.

Undercut or Knife Edge Ring Nozzle.



Diameter of Stream about $\frac{1}{8}$ inch smaller than orifice.

RING NOZZLES.

We find so many ring nozzles in use that it was thought best to prepare tables giving their discharge. The advocates of this style of nozzle stand up for its alleged merits stoutly, and therefore I tried some experiments intended to settle the question. Ring nozzles were prepared of such size as to discharge just the same number of gallons per minute as certain smooth nozzles, and the two, ring and smooth, then tested side by side. One set of these experiments is illustrated in the cut opposite. Another series of experiments was tried at another place, with jets more nearly horizontal. Both series of experiments were made with the greatest care, and at times when there was almost absolutely no wind; and were afterward repeated in the presence of the Corps of Inspectors.

These experiments all showed conclusively that the ring nozzle does not possess the slightest advantage over the smooth nozzle. The smooth nozzle proved slightly superior: its stream was more solid, and reached a little farther; this difference was very small, however.

Other experiments proved that a ring nozzle discharges only three quarters as much water per minute as a smooth nozzle of the same size. The sharp corner of the ring contracts the stream, and if any one will measure diameter of stream close to nozzle with a pair of common machinist's callipers, he will find it about $\frac{1}{8}$ inch smaller than the hole from which it issues.

The only use of the ring nozzle is to make a show of playing a larger stream than is the fact. The apparent advantage of the ring nozzle, which has misled many firemen, is easily explained. The result is the same as if a smaller nozzle were used, while hydrant pressure remained the same. The number of gallons per minute flowing being less, the pressure lost by friction through hose is less; therefore pressure at base of play-pipe remains greater, therefore stream goes higher.

For $\frac{7}{8}$ inch and 1 inch Ring Nozzles, the discharge is almost exactly the same as for smooth nozzles $\frac{1}{8}$ inch smaller; therefore no special tables for these two sizes of ring nozzles are given. For 7-8 inch Ring Nozzle use table for 3-4 inch Smooth Nozzle, and for 1 inch Ring Nozzle use table for 7-8 inch Smooth Nozzle.

(Discharge of 1-in. Ring is same as $\frac{7}{8}$ -in. Smooth.)
 (Discharge of $\frac{7}{8}$ -in. Ring is same as $\frac{3}{4}$ -in. Smooth.)

1 $\frac{1}{8}$ -INCH RING Hydrant Pressure Required — Discharge

INDICATED PRESSURE		Extreme Height of Jet.		Extreme Horizontal Distance reached by Jet.		Gallons per Minute Discharged.	Pounds Pressure Required at Hydrant (see first column, through)								
by Gauge attached at Base of Play-Pipe, and set level with End of Nozzle.		Average of Highest Drops, Vertical Jet, Still Air.		Maximum Limit of Distance as Good Effective Fire Stream with Moderate Wind.			Length 50 ft.			Length 100 ft.			Length 200 ft.		
		Average of Highest Drops, Vertical Jet, Still Air.		Maximum Limit of Distance as Good Effective Fire Stream with Moderate Wind.			Unlined Linen Hose.			Inferior Rubber-lined Cotton "Mill Hose."—Inside Rough.			Ordinary best quality Rubber-lined Hose.—Inside Smooth.		
		Average of Highest Drops, Vertical Jet, Still Air.		Maximum Limit of Distance as Good Effective Fire Stream with Moderate Wind.			Unlined Linen Hose.			Inferior Rubber-lined Cotton "Mill Hose."—Inside Rough.			Ordinary best quality Rubber-lined Hose.—Inside Smooth.		
		Average of Highest Drops, Vertical Jet, Still Air.		Maximum Limit of Distance as Good Effective Fire Stream with Moderate Wind.			Unlined Linen Hose.			Inferior Rubber-lined Cotton "Mill Hose."—Inside Rough.			Ordinary best quality Rubber-lined Hose.—Inside Smooth.		
		Average of Highest Drops, Vertical Jet, Still Air.		Maximum Limit of Distance as Good Effective Fire Stream with Moderate Wind.			Unlined Linen Hose.			Inferior Rubber-lined Cotton "Mill Hose."—Inside Rough.			Ordinary best quality Rubber-lined Hose.—Inside Smooth.		
Feble Streams.		lbs.	ft.	ft.	ft.		lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
5.		10	17	20	63	6	6	6	7	7	6	9	9		
10.		21	37	20	89	13	12	11	15	14	12	19	18		
15.		32	57	29	110	19	18	17	22	21	18	28	27		
20.		42	76	36	126	25	25	23	29	28	25	38	35		
Ordinary Fire Streams.															
25.		52	93	41	141	31	31	28	37	35	31	47	44		
30.		62	107	45	155	38	37	34	44	42	37	56	53		
35.		72	120	49	167	44	43	40	51	49	43	66	62		
40.		82	131	53	179	50	49	45	59	56	49	75	71		
Excellent.															
45.		91	141	56	190	56	55	51	66	63	55	85	80		
50.		99	150	59	200	63	61	57	73	70	61	94	88		
55.		107	158	62	210	69	67	63	80	77	67	103	97		
60.		115	164	65	219	75	74	68	88	84	74	113	106		
Unusually Strong Streams.															
(Difficult to hold Nozzle without special appliances.)															
65.		122	170	67	228	82	80	74	95	91	80	122	115		
70.		128	176	69	237	88	86	80	102	98	86	132	124		
75.		133	181	71	245	94	92	85	110	106	92	141	133		
80.		138	186	73	253	100	98	91	117	113	98	150	141		
Maximum															
85.		142	190	75	261	107	104	97	124	120	104	160	150		
90.		145	194	77	268	113	110	102	132	127	110	169	159		
95.		148	198	79	276	119	117	108	139	134	117	179	168		
100.		150	202	80	283	125	123	114	146	141	123	188	177		

NOTE.— The above figures for Ring Nozzle Discharges will apply to any ordinary of Ring accurately enough for practical purposes, but apply especially to ord form of Ring Nozzle with square shoulder $\frac{1}{16}$ or $\frac{1}{8}$ inch deep.
 Ring Nozzles with "undercut" or "knife-edge" shoulder, discharge, as ordin constructed, about three per cent. less than quantity given above.

OZZLE.

Height and Distance of Jet.

TABLE A.—No. 7.
(From experiments of
J. R. FREEMAN, 1889.)

aner) while stream is flowing, to maintain pressure at base of play-pipe, as per
ions lengths and kinds of 2½-inch Hose, as below.

Length 300 ft.			Length 400 ft.			Length 500 ft.			Length 600 ft.			Length 800 ft.			Length 1000 ft.		
Inferior Rubber-lined Cotton "Mill Hose,"—Inside Rough. Ordinary best quality Rubber- lined Hose.—Inside Smooth.			Unlined Linen Hose. Inferior Rubber-lined Cotton "Mill Hose,"—Inside Rough. Ordinary best quality Rubber- lined Hose.—Inside Smooth.			Unlined Linen Hose. Inferior Rubber-lined Cotton "Mill Hose,"—Inside Rough. Ordinary best quality Rubber- lined Hose.—Inside Smooth.			Unlined Linen Hose. Inferior Rubber-lined Cotton "Mill Hose,"—Inside Rough. Ordinary best quality Rubber- lined Hose.—Inside Smooth.			Unlined Linen Hose. Inferior Rubber-lined Cotton "Mill Hose,"—Inside Rough. Ordinary best quality Rubber- lined Hose.—Inside Smooth.			Unlined Linen Hose. Inferior Rubber-lined Cotton "Mill Hose,"—Inside Rough. Ordinary best quality Rubber- lined Hose.—Inside Smooth.		
lbs.	lbs.		lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
2	11	8	14	12	9	16	14	10	18	16	11	22	20	12	26	23	14
3	21	16	27	25	18	31	29	19	35	32	21	44	39	25	52	47	29
4	32	24	41	37	27	47	43	29	53	48	32	66	59	37	78	70	43
6	43	32	54	50	35	63	57	39	71	64	43	88	79	50	104	93	57
7	53	40	68	62	44	78	71	49	89	80	53	110	98	62	130	116	71
9	64	48	81	75	53	94	86	58	106	96	64	131	118	75	156	140	86
10	75	56	95	87	62	110	100	68	124	112	75	153	138	87	182	163	100
12	85	64	108	100	71	125	114	78	142	128	85	175	157	100	208	186	114
13	96	71	122	112	80	141	128	88	160	145	96	197	177	112	234	209	128
15	106	79	136	125	88	156	143	97	177	161	106	219	197	125	260	233	143
16	117	87	149	137	97	172	157	107	195	177	117	241	216	137	....	256	157
18	128	95	163	149	106	188	171	117	213	193	128	263	236	149	....	....	171
19	138	103	176	162	115	203	185	127	230	209	138	....	256	162	....	....	185
21	149	111	190	174	124	219	200	136	248	225	149	....	....	174	....	....	200
22	160	119	203	187	132	235	214	146	266	241	160	....	....	187	....	....	214
24	170	127	217	199	141	250	228	156	....	257	170	....	....	199	....	....	228
25	181	135	231	212	150	....	242	166	....	....	181	....	....	212	....	....	242
27	192	143	244	224	159	....	257	175	....	....	192	....	....	224	....	....	257
28	202	151	258	237	168	....	....	185	....	....	202	....	....	237	....	....	....
30	213	159	....	249	177	....	....	195	....	....	213	....	....	249	....	....	....

TAKE NOTICE.—The above is pressure at hydrant head *while stream is flowing*.
The corresponding Static Reservoir Pressure, or Fire-pump Pressure, must be
greater than hydrant pressure by an amount equal to friction loss between
hydrant-head and pump or reservoir.

1 1/4-INCH RING

Hydrant Pressure Required — Discharge

INDICATED PRESSURE by Gauge at- tached at Base of Play-Pipe, and set level with End of Nozzle.	Extreme Height of Jet.		Extreme Horizontal Distance reached by Jet.		Gallons per Minute Discharged.	Pounds Pressure Required at Hydrant (or first column, through								
	Average of Highest Drops, Vertical Jet, Still Air.		Maximum Limit of Height as Good Effective Fire Stream with Moderate Wind.			Length 50 ft.			Length 100 ft.			Length 200 ft.		
	lbs.	ft.	ft.	ft.		Unlined Linen Hose.	Inferior Rubber-lined Cotton "Mill Hose."—Inside Rough.	Ordinary best quality Rubber- lined Hose.—Inside Smooth.	Unlined Linen Hose.	Inferior Rubber-lined Cotton "Mill Hose."—Inside Rough.	Ordinary best quality Rubber- lined Hose.—Inside Smooth.	Unlined Linen Hose.	Inferior Rubber-lined Cotton "Mill Hose."—Inside Rough.	Ordinary best quality Rubber- lined Hose.—Inside Smooth.
Feeble Streams.	5.	11	20	21	79	7	7	6	9	8	7	12	11	8
	10.	21	17	39	111	14	13	12	17	16	13	24	22	16
	15.	32	26	58	136	21	20	18	26	24	20	35	33	24
	20.	43	36	78	157	28	27	24	34	33	27	47	44	33
Ordinary Fire Streams. Good.	25.	53	43	97	176	35	34	30	43	41	34	59	55	41
	30.	63	49	112	192	42	40	36	51	49	40	71	66	49
	35.	73	56	126	208	49	47	42	60	57	47	82	76	57
	40.	83	63	138	222	56	54	48	69	65	54	94	87	65
Excellent.	45.	93	68	149	236	63	61	54	77	73	61	106	98	73
	50.	102	72	157	248	70	67	61	86	81	67	118	109	81
	55.	111	76	164	260	77	74	67	94	90	74	130	120	90
	60.	119	79	172	272	84	81	73	103	98	81	141	131	98
Unusually Strong Streams. (Difficult to hold Nozzle without special appliances.)	65.	127	81	178	283	90	88	79	111	106	88	153	142	106
	70.	133	84	185	294	97	94	85	120	114	94	165	153	114
	75.	138	86	191	304	104	101	91	129	122	101	177	164	122
	80.	143	88	196	314	111	108	97	137	130	108	188	175	130
	85.	147	90	201	324	118	115	103	146	138	115	200	186	138
	90.	149	92	206	333	125	121	109	154	147	121	212	197	147
	95.	152	94	211	342	132	128	115	163	155	128	224	208	155
	100.	154	95	215	351	139	135	121	171	163	135	236	218	163

NOTE.— The above figures for Ring Nozzle Discharges will apply to any ordinary form of Ring accurately enough for practical purposes, but apply especially to ordinary form of Ring Nozzle with square shoulder $\frac{1}{8}$ or $\frac{1}{4}$ inch deep.
Ring Nozzles with "undercut" or "knife-edge" shoulder, discharge, as ordinarily constructed, about three per cent. less than quantity given above.

NOZZLE.

-Height and Distance of Jet.

TABLE A.—No. 8.
(From experiments of
J. R. FREEMAN, 1888.)

teamer) while stream is flowing, to maintain pressure at base of play-pipe, as per various lengths and kinds of 2½-inch Hose, as below.

Length 300 ft.			Length 400 ft.			Length 500 ft.			Length 600 ft.			Length 800 ft.			Length 1000 ft.		
Unlined Linen Hose.			Unlined Linen Hose.			Unlined Linen Hose.			Unlined Linen Hose.			Unlined Linen Hose.			Unlined Linen Hose.		
Inferior Rubber-lined Cotton "Mill Hose."—Inside Rough.			Inferior Rubber-lined Cotton "Mill Hose."—Inside Rough.			Inferior Rubber-lined Cotton "Mill Hose."—Inside Rough.			Inferior Rubber-lined Cotton "Mill Hose."—Inside Rough.			Inferior Rubber-lined Cotton "Mill Hose."—Inside Rough.			Inferior Rubber-lined Cotton "Mill Hose."—Inside Rough.		
Ordinary best quality Rubber-lined Hose.—Inside Smooth.			Ordinary best quality Rubber-lined Hose.—Inside Smooth.			Ordinary best quality Rubber-lined Hose.—Inside Smooth.			Ordinary best quality Rubber-lined Hose.—Inside Smooth.			Ordinary best quality Rubber-lined Hose.—Inside Smooth.			Ordinary best quality Rubber-lined Hose.—Inside Smooth.		
lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
15	14	10	18	17	11	21	19	12	25	22	14	31	28	17	38	33	19
30	27	19	36	33	22	43	39	25	49	44	27	62	55	33	75	66	39
45	41	29	55	49	33	64	58	37	74	66	41	93	83	49	112	100	58
60	55	38	73	66	44	86	77	49	99	88	55	124	111	66	150	133	77
75	69	48	91	83	55	107	96	62	123	110	69	155	138	83	187	166	96
90	82	57	109	99	66	128	116	74	148	132	82	186	166	99	225	199	116
105	96	67	127	115	76	150	135	86	172	154	96	217	193	115	262	232	135
120	110	76	146	132	87	171	154	99	197	176	110	248	221	132	....	266	154
135	123	86	164	148	98	193	173	111	222	199	123	279	249	148	....	....	173
150	137	95	182	165	109	214	193	123	246	221	137	....	276	165	....	....	193
165	151	105	200	181	120	236	212	135	271	243	151	....	....	181	....	....	212
180	164	114	218	198	131	257	231	148	....	265	164	....	....	198	....	....	231
195	178	124	237	214	142	....	251	160	....	....	178	....	....	214	....	....	251
210	192	133	255	231	153	....	....	172	....	....	192	....	....	231	....	....	....
225	206	143	....	247	164	....	....	185	....	....	206	....	....	247	....	....	....
240	219	152	....	264	175	....	....	197	....	....	219	....	....	264	....	....	....
255	233	162	....	....	186	....	....	209	....	....	233	....	....	....	....	....	....
....	247	172	....	....	197	....	....	222	....	....	247	....	....	....	....	....	....
....	260	181	....	....	208	....	....	234	....	....	260	....	....	....	....	....	....
....	....	191	....	....	218	....	....	246	....	....	....	....	....	....	....	....	....

TAKE NOTICE.—The above is pressure at hydrant head *while stream is flowing*. The corresponding Static Reservoir Pressure, or Fire-pump Pressure, must be greater than hydrant pressure by an amount equal to friction loss between hydrant-head and pump or reservoir.

1 3/8-INCH RIN

Hydrant Pressure Required — Dischar

INDICATED PRESSURE		Extreme Height of Jet.		Extreme Horizontal Distance reached by Jet.		Gallons per Minute Discharged.	Pounds Pressure Required at Hydrant first column, thro											
		Average of Highest Drops, Vertical Jet, Still Air.		Maximum Limit of Distance as Good Effective Fire Stream with Moderate Wind.			Length 50 ft.				Length 100 ft.				Length 20			
		lbs.	ft.	ft.	ft.		Unlined Linen Hose.	Inferior Rubber-lined Cotton "Mill Hose."—Inside Rough.	Ordinary best quality Rubber- lined Hose.—Inside Smooth.	Unlined Linen Hose.	Inferior Rubber-lined Cotton "Mill Hose."—Inside Rough.	Ordinary best quality Rubber- lined Hose.—Inside Smooth.	Unlined Linen Hose.	Inferior Rubber-lined Cotton "Mill Hose."—Inside Rough.	Ordinary best quality Rubber- lined Hose.—Inside Smooth.			
Feeble Streams.		lbs.	ft.	ft.	ft.		lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.			
5.		11			20	96	8	8	7	10	10	8	15	14				
10.		22			39	136	16	15	13	21	19	15	30	28				
15.		32			59	166	24	23	20	31	29	23	45	41				
20.		43			79	192	32	30	26	41	39	30	60	55				
Ordinary Fire Streams.		lbs.	ft.	ft.	ft.		lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.			
25.		53			99	214	40	38	33	52	48	38	75	69				
30.		64			116	235	48	46	39	62	58	46	91	83				
35.		74			131	253	55	53	46	72	68	53	106	97				
40.		85			144	271	63	61	53	82	77	61	121	111				
45.		95			154	287	71	68	59	93	87	68	136	124				
50.		105			164	303	79	76	66	103	97	76	151	138				
55.		114			172	318	87	84	72	113	106	84	166	152				
60.		123			180	332	95	91	79	124	116	91	181	166				
Unusually Strong Streams. (Difficult to hold Nozzle without special appliances.)		lbs.	ft.	ft.	ft.		lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.			
65.		131			187	346	103	99	85	134	126	99	196	180				
70.		137			194	359	111	106	92	144	135	106	211	193				
75.		142			200	371	119	114	98	155	145	114	226	207				
80.		147			206	383	127	122	105	165	155	122	241	221				
85.		150			212	395	135	129	112	175	164	129	257	235				
90.		153			217	407	143	137	118	186	174	137	....	249				
95.		156			222	418	150	144	125	196	184	144	....	263				
100.		158			227	429	158	152	131	206	193	152	....	....				

NOTE.— The above figures for Ring Nozzle Discharges will apply to any ordinary
of Ring accurately enough for practical purposes, but apply especially to ordi
form of Ring Nozzle with square shoulder 1/16 or 1/8 inch deep.

Ring Nozzles with "undercut" or "knife-edge" shoulder, discharge, as ordin
constructed, about three per cent. less than quantity given above.

1 3/8 r.

NOZZLE.

Height and Distance of Jet.

TABLE A.—No. 9.
(From experiments of
J. R. FREEMAN, 1888.)

camera) while stream is flowing, to maintain pressure at base of play-pipe, as per various lengths and kinds of 2½-inch Hose, as below.

Length 300 ft.			Length 400 ft.			Length 500 ft.			Length 600 ft.			Length 800 ft.			Length 1000 ft.		
Inferior Rubber-lined Cotton "Mill Hose,"—Inside Rough.			Unlined Linen Hose.			Inferior Rubber-lined Cotton "Mill Hose,"—Inside Rough.			Unlined Linen Hose.			Inferior Rubber-lined Cotton "Mill Hose,"—Inside Rough.			Unlined Linen Hose.		
Ordinary best quality Rubber-lined Hose.—Inside Smooth.			Inferior Rubber-lined Cotton "Mill Hose,"—Inside Rough.			Ordinary best quality Rubber-lined Hose.—Inside Smooth.			Ordinary best quality Rubber-lined Hose.—Inside Smooth.			Ordinary best quality Rubber-lined Hose.—Inside Smooth.			Ordinary best quality Rubber-lined Hose.—Inside Smooth.		
lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
20	18	12	25	22	14	29	26	16	34	30	18	44	39	22	53	47	26
40	36	24	49	44	28	59	53	32	68	61	36	88	77	44	107	94	53
50	54	35	74	66	41	88	79	48	103	91	54	131	116	66	160	141	79
79	72	47	99	88	55	118	105	64	137	122	72	175	155	88	213	188	105
99	90	59	123	111	69	147	131	79	171	152	90	219	193	111	267	235	131
19	108	70	148	133	83	177	157	95	205	182	108	263	232	133	....	282	157
39	126	82	173	155	97	206	184	111	240	213	126	....	271	155	....	....	184
59	144	94	197	177	111	236	210	127	274	243	144	....	....	177	....	....	210
79	162	106	222	199	124	265	236	143	....	274	162	....	....	199	....	....	236
99	180	117	247	221	138	....	263	159	....	....	180	....	....	221	....	....	263
19	198	129	271	243	152	....	....	175	....	....	198	....	....	243	....	....	....
38	216	141	....	265	166	....	....	191	....	....	216	....	....	265	....	....	....
58	234	153	....	....	180	....	....	207	....	....	234	....	....	....	....	....	....
...	251	164	....	....	193	....	....	222	....	....	251	....	....	....	....	....	....
...	...	176	....	....	207	....	....	238	....	....	....	....	....	....	....	....	....
...	...	188	....	....	221	....	....	254	....	....	....	....	....	....	....	....	....
...	...	200	....	....	235	....	....	....	....	....	....	....	....	....	....	....	....
...	...	211	....	....	249	....	....	....	....	....	....	....	....	....	....	....	....
...	...	223	....	....	263	....	....	....	....	....	....	....	....	....	....	....	....
...	...	235	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....

TAKE NOTICE.—The above is pressure at hydrant head *while stream is flowing*. The corresponding Static Reservoir Pressure, or Fire-pump Pressure, must be greater than hydrant pressure by an amount equal to friction loss between hydrant-head and pump or reservoir.

PUMP INSPECTION TABLES.

Tables B No. 1 and B No. 2 are the tables designed for regular use in testing a pump to see if it will throw its rated capacity. Somewhat greater accuracy can be obtained with B No. 1, using only 50 ft. of hose, than with greater lengths of hose.

The "Open Butt" table, though not giving the same degree of accuracy as the nozzle table, is of frequent use where there are not conveniences available for testing the whole number of separate fire-streams that a pump can throw, and is also of use in determining the reduction of pressure on sprinklers from a reservoir or city supply brought through a long pipe, which occurs when the equivalent of say four, six, or ten 240-gallon streams is drawn from the pipes.

It is preferable to use a 1 1/8 inch smooth nozzle in tests of pumps, as this is none too large for furnishing a practical and effective stream. If none are available, it is well to smoothly bore out some of the smaller nozzles (especially ring nozzles) to this size, before making a test, and then urge that some Standard Nozzles be procured by the next express. **The use of small nozzles in a test is almost certain to give a mill superintendent an entirely erroneous idea of the efficiency of his apparatus.**

Mill superintendents often object to wetting so much hose as is required for testing the full capacity of their pumps.

Linen hose is undoubtedly injured each time it is wet, but it is stated by the leading manufacturers of rubber-lined hose that **rubber-lined cotton hose is improved** rather than injured by **having a stream of water run through it occasionally** if it be well dried and aired afterward. It is said this tends to wash out any excess of sulphur and tends to prevent the lining of the hose from sticking together, and it is said that in many fire departments the rubber in hose which is used occasionally, retains its strength and pliability longer than spare hose which is not used.

For other reasons rubber-lined cotton-hose is better adapted for use on yard hydrants than linen. However, it can ordinarily be arranged to test one pump at a time, and it is very rare that a fire pump will be found which can throw more than four good 1 1/8 inch streams. **There is no such good way of finding out the condition of a pump as by seeing how many good streams it can throw.**

Testing pumps in this manner has the further advantage that the men in charge learn the capacity of their pumps, and are more likely to **in case of fire, avoid the frequent and often fatal error of attaching more lines of hose than the pump can possibly supply, thus crippling all the streams.**

In testing pumps it is generally worse than useless to run the water pressure up above 125 lbs. at the highest, and ordinarily 100 lbs. should not be exceeded. To test the capacity of a pump does not mean to find what is the utmost height to which pressure can be raised. The true test for capacity is: How many good practical fire streams will the pump throw?

Horse Power Required for Rotary Pumps.

The theoretical amount of power necessary to give a pressure of 100 lbs. per square inch, with a delivery of 100 gallons per minute, is 5.84 H. P. This includes no allowance whatever for friction of water, or of the pump itself, or for slip. Practical experience shows these to about double the power necessary, and for a rotary pump of the best make in good order **12 horse power for each 100 gallons per minute at a first-class fire pressure, is not too much to allow, or say at least 30 horse-power for each good 1 1-8 inch stream.**

PLAY-PIPES AND NOZZLES.

Most members of the corps of inspectors will, I think, agree with me in the statement, that half the play-pipes and nozzles found at the average mill ought to be sent to the scrap-heap. Often a lack of appreciation of the real needs, or sometimes a pinching false economy, will throw away ten per cent. of the efficiency of a two-thousand dollar pump and hydrant system, in order to save two or three dollars apiece on the few play-pipes needed.

A play-pipe that is battered and bruised, or rough on the inside, due to drops of solder, or sharp projecting corners, can not throw a good, clean, far-reaching stream. Neither can the cheap, cast brass play-pipes, which, though nicely polished on the outside, are left as rough on the inside as when they came from the brass foundry, excepting only an inch or two at the tip.

For the best efficiency, the inside of a play-pipe and nozzle must be smooth as a gun barrel.

Swivel Handles attached to the base of a play-pipe are absolutely essential to a good play-pipe for mill fire protection. A play-pipe for use on hose from yard hydrants ought never to be without handles, and, in my opinion, they are to be always recommended for all 2-inch or 2½-inch hose on the inside stand-pipes.

The short cast brass play-pipes 12 inches or 18 inches, or even 20 inches long, without handles, which are occasionally found attached to 2½-inch hose even for yard hydrant use, are awkward to use, and liable to lead to accident, and are unworthy a place in the equipment of any good mill.

There is a heavy recoil from the powerful streams needed for mill

fires. The average mill-fireman gets much less practice in holding these stiff streams than a professional fireman. No professional fireman would tolerate play-pipes without handles; mill firemen need them still more. Such handles make it much easier to hold the pipe, to take up a ladder, or to shift its location on the ground. Absence of handles frequently allows play-pipe to get away from the pipe-man. One member of our corps has seen a man's arm broken, another has seen a man's leg broken, and another inspector has seen a man's scalp peek open by the thrashing around of a play-pipe which had pulled itself away from the hose-man.

Drawings for a **Standard Mill Play-Pipe and nozzle*** have been prepared by the writer, and copies placed in the hands of all the leading manufacturers of such apparatus. There is no patent on any part of it, and there is nothing specially novel about it: it is merely a combination of elements which experiment and actual service show give the best results. A nozzle of this form was found to give a better stream than any form of fancy nozzle tested. The nozzle is shown in figure at top of page 23. The throat of pipe is larger than common, being $1\frac{3}{4}$ -inch diameter; the nozzle is a true taper, with corner at end of taper rounded off on an easy curve; straight part at end of taper short; washer at base of nozzle is placed outside, to avoid the frequent projection of a ragged corner into waterway; a lip covers washer to prevent it being blown out; the body of pipe is wound with cord to give a better grip and make it feel less like holding a big icicle in freezing weather.

Play-pipes for mill equipment had best be of brass throughout. Rubber or fabric play-pipes, though excellent for city department use, are liable to go to pieces in five or ten years, by rotting of the rubber.

* Called in some cases the "Underwriter Pipe," or the "Factory Mutual Pipe." Net cost, about \$7.50 each. Can be procured from Boston Woven Hose Co., 234 Devonshire St., Boston; Eureka Fire Hose Co., 13 Barclay St., New York; A. Morse & Son, 140 Congress St., Boston, and Allen Fire Department Supply Company, Providence, R. I.

BEST SIZE FOR NOZZLES.

This varies somewhat with the possible magnitude of the fire and the quantity of water available at good pressure; moreover with very long lines of hose smaller nozzles have to be used.

In general, the $1\frac{1}{8}$ -inch smooth nozzle is the size best adapted for the equipment of the ordinary mill, and, in connection with yard hydrants, nothing smaller than this should ordinarily be used, except for very small mills, or where pump capacity is small.

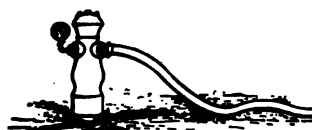
For large mills it is well to have half of the nozzles of $1\frac{1}{4}$ -inch diameter.

The general tendency of the experience of the past 15 years is toward larger nozzles.

The stream from a small nozzle thrown on a large fire is converted into steam without ever reaching the seat of the fire; while from a larger nozzle, though the same amount as before be evaporated, enough water may be left to pass through the flames to the coals themselves, thus extinguishing the fire. Thus, on a large fire the same quantity of water will do far more work if concentrated in one good $1\frac{1}{4}$ -inch stream than it will in the form of two $\frac{3}{8}$ -inch streams.

The writer had an excellent chance to study this as an eye-witness at the partial burning of a large mill in 1886, and was most thoroughly convinced of the superiority of the large nozzle.

A steam fire-pump in good order will generally throw 85 to 95 per cent. of plunger displacement. The loss of action with steam fire-pumps is mainly due to "short stroke." The capacity of City Steam Fire-engines is often greatly over-rated. A No. 1 Holyoke Rotary Fire-pump will in general throw as much water as three City Steam Fire-engines.



PUMP INSPEC

Discharge of Nozzles at

HYDRANT PRESSURE	1 3/8-Inch Smooth Nozzle.			1 1/4-Inch Smooth Nozzle.			1 1/8-Inch Smooth Nozzle.			1-Inch Smooth Nozzle.			Sm or
	Gals. per Min.			Gals. per Min.			Gals. per Min.			Gals. per Min.			Ga
	Unlined Linen Hose.	Inferior Rubber-lined Cotton "Mill Hose."—Inside Rough.	Ordinary best quality Rubber- lined Hose.—Inside Smooth.	Unlined Linen Hose.	Inferior Rubber-lined Cotton "Mill Hose."—Inside Rough.	Ordinary best quality Rubber- lined Hose.—Inside Smooth.	Unlined Linen Hose.	Inferior Rubber-lined Cotton "Mill Hose."—Inside Rough.	Ordinary best quality Rubber- lined Hose.—Inside Smooth.	Unlined Linen Hose.	Inferior Rubber-lined Cotton "Mill Hose."—Inside Rough.	Ordinary best quality Rubber- lined Hose.—Inside Smooth.	Unlined Linen Hose.
Indicated while Stream is flowing by Gauge attached to Hydrant, as shown.													
Lbs. per sq. in.													
5	90	92	103	80	82	90	70	71	75	59	59	62	4
10	127	131	146	114	116	127	99	101	107	83	84	87	6
15	155	160	179	140	143	154	121	123	131	101	102	106	8
20	180	185	206	161	164	179	140	142	151	117	118	123	9
25	201	207	230	180	184	200	156	158	169	131	132	137	10
30	220	226	251	197	202	219	171	173	184	143	144	150	11
35	238	245	272	213	218	236	184	188	199	154	156	162	12
40	255	262	291	227	233	253	197	201	213	165	167	173	13
45	270	278	309	241	247	269	209	213	226	175	177	184	14
50	284	293	325	255	260	283	221	224	238	184	186	194	14
55	298	307	341	267	273	296	232	235	250	193	195	204	15
60	311	320	357	279	285	309	242	245	261	202	204	213	16
65	324	333	371	290	296	322	252	255	272	210	213	221	16
70	336	346	385	301	307	334	261	265	281	218	221	230	17
75	348	358	399	311	318	344	270	275	291	226	228	238	18
80	359	370	412	322	329	357	279	284	301	233	236	246	18
85	371	382	425	332	339	369	288	293	310	240	243	253	19
90	381	393	437	341	349	379	296	301	319	247	250	261	19
95	392	403	449	350	358	390	304	309	328	253	257	268	20
100	402	414	461	359	368	400	312	317	337	260	264	275	20

Quantities are stated in United States gallons of 231 cubic inches

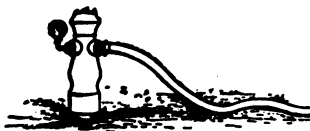
LES.

Feet of 2½-Inch Hose.

TABLE B.—No. 1.
(From experiments of
J. R. FREEMAN, 1888.)

1 3/8-Inch Ring Nozzle.				1 1/4-Inch Ring Nozzle.				1 1/8-Inch Ring Nozzle.				HYDRANT PRESSURE.
Gals. per Min.				Gals. per Min.				Gals. per Min.				
Unlined Linen Hose.				Unlined Linen Hose.				Unlined Linen Hose.				
Inferior Rubber-lined Cotton "Mill Hose."—Inside Rough.				Inferior Rubber-lined Cotton "Mill Hose."—Inside Rough.				Inferior Rubber-lined Cotton "Mill Hose."—Inside Rough.				
Ordinary best quality Rubber-lined Hose.—Inside Smooth.				Ordinary best quality Rubber-lined Hose.—Inside Smooth.				Ordinary best quality Rubber-lined Hose.—Inside Smooth.				1 1/2 in. per sq. in.
6	37	75	76	84	66	67	70	56	56	59	5	
10	51	108	110	118	94	96	101	80	81	84	10	
11	62	132	135	144	115	117	124	98	99	103	15	
11	72	152	155	167	133	135	143	113	114	119	20	
30	81	170	174	187	149	151	159	126	128	133	25	
37	88	187	191	205	163	165	175	138	140	145	30	
33	95	201	206	221	176	179	189	149	151	157	35	
30	101	215	219	237	188	191	202	159	162	168	40	
36	108	229	233	251	200	203	214	169	172	178	45	
42	113	241	245	264	211	214	226	179	181	188	50	
47	119	253	257	277	221	224	237	187	189	197	55	
52	124	264	269	289	231	234	247	196	198	205	60	
57	129	275	280	301	240	244	257	205	206	214	65	
32	134	285	291	313	249	253	267	212	213	222	70	
37	139	295	301	324	258	262	276	219	221	230	75	
42	144	305	311	334	266	270	285	226	228	237	80	
46	148	314	320	345	274	279	294	233	235	244	85	
50	152	323	329	355	282	287	303	239	242	252	90	
54	156	332	338	364	290	295	311	246	249	259	95	
59	161	340	347	374	298	303	319	253	255	266	100	

—The above figures for Ring Nozzle Discharges will apply to any ordinary form of Ring Nozzle sufficiently accurate for practical purposes, but apply especially to ordinary form of Ring Nozzle with square shoulder $\frac{1}{8}$ or $\frac{1}{4}$ inch deep. Nozzles with "under-cut" or "knife-edge" shoulder, discharge, as ordinarily constructed, about 3 per cent. less than quantity given above.



PUMP INSPI

Discharge of Nozzles

HYDRANT PRESSURE	1 3/8-Inch Smooth Nozzle.			1 1/4-Inch Smooth Nozzle.			1 1/8-Inch Smooth Nozzle.			1-Inch Smooth Nozzle.		
	Gals. per Min.			Gals. per Min.			Gals. per Min.			Gals. per Min.		
	Unlined Linen Hose.	Inferior Rubber-lined Cotton "Mill Hose."—Inside Rough.		Unlined Linen Hose.	Inferior Rubber-lined Cotton "Mill Hose."—Inside Rough.		Unlined Linen Hose.	Inferior Rubber-lined Cotton "Mill Hose."—Inside Rough.		Unlined Linen Hose.	Inferior Rubber-lined Cotton "Mill Hose."—Inside Rough.	
		Ordinary best quality Rubber- lined Hose.—Inside Smooth.			Ordinary best quality Rubber- lined Hose.—Inside Smooth.			Ordinary best quality Rubber- lined Hose.—Inside Smooth.			Ordinary best quality Rubber- lined Hose.—Inside Smooth.	
Lbs. per sq. in.												
5	75	79	93	70	72	82	62	64	71	54	55	59
10	107	111	131	98	102	116	88	91	100	76	78	83
15	131	136	160	121	125	143	108	111	123	93	95	102
20	151	157	185	139	144	164	125	128	142	107	110	118
25	169	176	207	155	161	184	139	143	158	120	122	132
30	185	192	226	170	176	202	152	156	173	132	134	144
35	200	208	245	184	190	218	165	169	188	142	145	156
40	214	222	262	197	204	233	176	181	201	152	155	167
45	226	236	278	209	216	247	187	192	213	161	165	177
50	239	249	293	220	228	260	197	202	224	170	174	186
55	251	261	307	231	239	273	207	212	235	178	182	195
60	261	273	320	241	250	285	216	222	245	186	190	204
65	272	284	333	251	260	296	225	231	255	194	198	213
70	282	294	346	261	270	307	233	240	265	201	205	221
75	292	304	358	270	279	319	241	248	275	208	212	228
80	301	314	370	278	288	329	249	256	284	215	219	236
85	311	324	382	287	297	339	257	264	293	222	226	243
90	320	333	393	295	306	349	264	272	301	228	233	250
95	329	342	403	303	314	358	272	279	309	234	239	257
100	337	351	414	311	322	368	279	287	317	240	245	264

Quantities are stated in United States gallons of 231 cubic in

TABLES.

TABLE B.—No. 2.
(From experiments of)
J. R. FREEMAN, 1884.

100 Feet of 2½-Inch Hose.

¾-Inch Nozzle, ¾-Inch Ring Nozzle. Gals. per Min.			1⅜-Inch Ring Nozzle. Gals. per Min.			1¼-Inch Ring Nozzle. Gals. per Min.			1⅛-Inch Ring Nozzle. Gals. per Min.			HYDRANT PRESSURE.
Unlined Lining Hose.	Inferior Rubber-lined Cotton "Mill Hose."—Inside Rough.	Ordinary best quality Rubber-lined Hose.—Inside Smooth.	Unlined Lining Hose.	Inferior Rubber-lined Cotton "Mill Hose."—Inside Rough.	Ordinary best quality Rubber-lined Hose.—Inside Smooth.	Unlined Lining Hose.	Inferior Rubber-lined Cotton "Mill Hose."—Inside Rough.	Ordinary best quality Rubber-lined Hose.—Inside Smooth.	Unlined Lining Hose.	Inferior Rubber-lined Cotton "Mill Hose."—Inside Rough.	Ordinary best quality Rubber-lined Hose.—Inside Smooth.	Lbs. per sq. in.
34	34	35	67	69	78	60	62	68	52	53	57	5
48	49	50	94	97	110	85	87	96	74	75	81	10
59	60	61	115	120	135	104	107	117	90	92	99	15
68	69	71	133	138	155	120	123	135	105	107	114	20
76	77	79	149	154	174	134	138	151	117	119	128	25
84	84	87	163	169	191	147	151	165	128	130	140	30
90	91	93	176	182	206	159	163	179	139	141	151	35
97	97	100	188	195	219	169	174	191	148	151	162	40
103	103	106	200	207	233	180	185	203	157	160	172	45
108	109	112	211	218	245	190	195	214	165	169	181	50
113	114	117	221	229	257	199	204	224	173	177	189	55
118	119	122	231	239	269	208	213	234	181	185	198	60
123	124	127	241	248	280	217	222	244	189	192	206	65
128	129	132	250	258	291	225	230	253	195	199	213	70
132	133	137	259	267	301	233	239	262	203	206	221	75
137	138	142	267	275	311	240	246	270	209	213	228	80
141	142	146	275	284	320	247	254	279	215	219	235	85
145	146	150	283	292	329	255	261	287	222	226	242	90
149	150	154	291	300	338	262	269	295	228	232	249	95
153	154	158	299	308	347	269	275	302	234	238	255	100

TE. — The above figures for Ring Nozzle Discharges will apply to any ordinary form of Ring accurately enough for practical purposes, but apply especially to ordinary form of Ring Nozzle with square shoulder $\frac{1}{8}$ or $\frac{1}{4}$ inch deep.
g Nozzles with "under-cut" or "knife-edge" shoulder, discharge, as ordinarily constructed, about 3 per cent. less than quantity given above.



(If Gauge is not connected in this manner, proper allowance must be made for loss of pressure between Gauge and Hydrant.)

PUMP INSPECTI

The degree of accuracy attained in esti
of the two preceding tables — B, No.

HYDRANT PRESSURE	Quantity of Water Discharged per minute through ordinary 2½-inch Fi (United States Gallons of 231 cubic inches.) Open Hose Butt. |								
	Length 25 feet.			Length 50 feet.			Length 100 f		
	Unlined Linen Hose.	Inferior Rubber- lined Cotton "Mill Hose."	Ordinary best quality Rubber- lined Hose.	Unlined Linen Hose.	Inferior Rubber- lined Cotton "Mill Hose."	Ordinary best quality Rubber- lined Hose.	Unlined Linen Hose.	Inferior Rubber- lined Cotton "Mill Hose."	
Lbs. per sq. in.	Inside Rough.	Inside Smooth.		Inside Rough.	Inside Smooth.		Inside Rough.	Inside Smooth.	
10	231	242	297	176	188	242	132	140	
15	283	297	363	217	230	297	161	171	
20	326	343	419	251	266	343	186	199	
25	365	383	468	281	297	383	208	222	
30	greater.	greater.	greater.	greater.	greater.	greater.	greater.		
35	400	420	514	307	326	420	228	243	
40	432	453	554	332	352	453	246	262	
45	462	484	593	355	376	484	264	280	
	490	514	630	377	399	514	280	297	
50	discharge would	discharge would	discharge would	discharge would	discharge would	discharge would	discharge would		
55	516	542	664	398	420	542	294	313	
60	541	568	696	416	440	568	308	328	
65	565	594	726	434	460	594	322	343	
	588	618	756	452	480	618	336	358	
70	were of Style A.	were of Style A.	were of Style A.	were of Style A.	were of Style A.	were of Style A.	were of Style A.		
75	610	641	784	470	498	641	348	371	
80	632	663	812	486	515	663	360	384	
85	652	685	....	502	532	685	372	397	
	672	706	....	518	548	706	383	409	
90	If Hydrant	If Hydrant	If Hydrant	If Hydrant	If Hydrant	If Hydrant	If Hydrant		
95	692	727	....	533	564	727	394	421	
100	712	747	....	547	579	747	405	432	
110	730	766	....	561	594	766	416	443	
120	766	806	....	588	623	806	436	465	
	800	....	....	614	651	....	456	486	

NOTE. — The above values are based on experiments with these kinds of Hose at to a Chapin 4-way Independent Gate Hydrant (Coeff. Disch. by Expt. 0.71 far as influence of kind of Hydrant upon discharge is concerned, the same are correct enough for practical purposes, except as noted in margin of colu It will be noted that this table gives, for each length, the discharge through the smoothest hose, and gives, also, discharge for same length of Hose with rou water-way. By use of a little judgment in interpolating between these two error, in ordinary use of table need not exceed 10 per cent.

LES.—“Open Butts.”

TABLE B.—No. 3.

through “Open Butt” is, not nearly so great as may be attained by the methods — by reason of greater influence of form of Hydrant and differences in Hose.

Discharge through Open Butt of Hydrant, without Hose attached.			NOTE.—Slight peculiarities of construction in different makes of Hydrants so affect discharge from open butts of Hydrants without Hose, that these figures apply only approximately to discharge of Hydrants in general.	
Discharge through 2½-inch Bore. Nozzle attached.	HYDRANT PRESSURE		By using good Judgment in applying corrections as per notes below, results accurate to within 10 per cent. may generally be obtained.	
10 feet.	Length 400 feet.	Indicated while Stream is flowing by Gauge attached to Hydrant, as shown.	Discharge of One Nipple of Chapman 4-Way Independent Gate Hydrant.	
Ordinary best quality Rubber-lined Hose.	Inferior Rubber-lined Cotton “Mill Hose.”	Ordinary best quality Rubber-lined Hose.	Diameter of Outlet exactly 2½ inches.	
Inside Smooth.	Inside Rough.	Inside Smooth.	Lbs. per sq. in.	Gals. per Min.
140	74	102	10	419
171	90	125	15	513
199	104	144	20	592
222	116	161	25	663
243	127	177	30	725
262	137	190	35	783
280	146	204	40	837
297	155	217	45	888
313	164	228	50	936
328	172	239	55	982
343	179	250	60	1026
358	186	260	65	1067
371	194	270	70	1108
384	201	279	75	1147
397	208	288	80	1184
409	215	297	85	1221
421	221	306	90	1256
432	227	314	95	1290
443	232	322	100	1326
465	243	338	110	....
486	254	354	120	....

NOTE.—Slight peculiarities of construction in different makes of Hydrants so affect discharge from open butts of Hydrants without Hose, that these figures apply only approximately to discharge of Hydrants in general.

By using good Judgment in applying corrections as per notes below, results accurate to within 10 per cent. may generally be obtained.

(Style A.)—Ordinary Matthews (R. D. Wood & Co.’s) Hydrant without independent gates, inside corner being rounded off, will probably discharge about 20 per cent. more.

(Style B.)—Ordinary Chapman Hydrants without independent gates have square inside corners, and will probably discharge about 10 per cent. more.

For the ordinary Ludlow and Lowry Independent-Gate Hydrants or Chucks, figures in table are probably nearly correct.

If diameter of outlet is not exactly 2½ inches, an additional correction, as follows, must be made:—

Diameter.	Add.	Deduct.
2⅝	10 %	....
2⅞	5 %	....
2⅞	....	5 %
2⅞	....	10 %
2⅞	....	19 %

ROTARY FIRE

DATA AS GIVEN BY BUILDER.

(April, 1889.)

Name of Pump.	Width of Face of Buckets.	Distance between Centres of Bucket Shafts.	Diameter of Pipes. (For short lengths.)		Proper Speed.	Nominal Discharge per Revolution.	Nominal Discharge at Usual Speed.		at 100 lbs. Pump Pressure, to be relied on after 5 years' ordinary occasional use.					
			Suction.	Discharge.			Rev. per Min.	Gals. per Min.	Size.	No.	Size.	No.		
	Ins.	Ins.	Ins.	Ins.	Rev. per Min.	Gals.								
<i>Holyoke No. 1</i>	10	8 $\frac{3}{10}$	6	6	250	4	250	1000						
<i>Machine 2</i>	9	8	6	5	275	3	275	825						
<i>Co. 3</i>	8 $\frac{1}{2}$	7 $\frac{2}{10}$	5	4	300	2	275	550						
<i>Holyoke, Mass.</i>														
<i>Fales & No. 4</i>	9	9	6	5	250 to 275	3 $\frac{7}{8}$	250	969						
<i>Jenks. 5</i>	9	8	6	5	250 to 300	2 $\frac{7}{8}$	275	791						
<i>Pawtucket, R.I. 6</i>	8 $\frac{1}{2}$	7	4	4	250 to 300	1 $\frac{2}{3}$	275	458						
	7	6 $\frac{1}{2}$	4	3	250 to 325	1 $\frac{1}{3}$	300	400						
	7 $\frac{1}{2}$	6 $\frac{1}{2}$	5	3	250 to 325	$\frac{2}{3}$	300	200						
<i>Clark, No. 1</i>	....	....	2 $\frac{1}{2}$	2 $\frac{1}{2}$	200 to 600	1 $\frac{1}{3}$	400	133						
<i>Turner's Falls, 2</i>	....	....	3	3	200 to 400	$\frac{3}{4}$	300	225						
<i>Mass. 3</i>	8	5 $\frac{1}{2}$	3 $\frac{1}{2}$	3 $\frac{1}{2}$	200 to 400	1	300	300						
<i>"Nonesuch." 4</i>	8	6 $\frac{1}{2}$	4 $\frac{1}{2}$	4 $\frac{1}{2}$	200 to 400	1 $\frac{1}{2}$	275	412						
	10	6 $\frac{1}{2}$	5	5	200 to 350	2	275	550						
	12	8	6	6	200 to 350	3	275	825						
<i>Wm. Clark No. 1</i>	5 $\frac{1}{4}$	5 $\frac{1}{4}$	3	2 $\frac{1}{2}$	200 to 500	$\frac{6}{10}$	350	210						
<i>& Co. 2</i>	6	6	3	3	200 to 500	1	300	300						
<i>Pittsfield, Mass. 3</i>	7	7	5	4	150 to 450	1 $\frac{1}{2}$	275	412						
<i>"Twin Rotary." 4</i>	8	8	5	5	150 to 450	2	275	550						
	9	9	6	6	100 to 350	3	275	825						
	....	....	8	8	100 to 325	4	250	1000						
	10	10	....	....	....	....	....	....						

The discharge of Rotary Fire-Pumps will generally be found to be much below the capacity at which they are tabled by their makers. The catalogue capacity only includes no allowance for slip, loss of action, or leakage back through the cracks between the buckets and the case. This at high pressures is rather large, even with a new and first-class rotary pump, and rotary pumps are machines which rapidly deteriorate in respect to quantity delivered, when subjected to wear and

MP TABLE.

DATA AS GIVEN BY BUILDER.

(April, 1889.)

Name of Pump.	Width of Face of Buckets.		Distance between Centres of Bucket Shafts.		Diameter of Pipes. (For short lengths.)		Proper Speed.	Nominal Discharge per Revolution.	Nominal Discharge at Usual Speed.		Fire Streams at 100 lbs. Pump Pressure, to be relied on after 3 years' ordinary occasional use.			
	Ins.	Ins.	Ins.	Ins.	Rev. per Min.	Gals.			Rev. per Min.	Gals. per Min.	Size.	Size.	No.	No.
No. 2	2	5	2	2	.....	$\frac{1}{3}$	.....	.....	.....	.....	.....	.....	.....	.....
Co.	3	4	5	3	3	to 325	$\frac{2}{3}$	300	200	.....	.....	.....	.....	.....
ort, N.Y.	4	5	$7\frac{1}{4}$	4	4	to 380	$1\frac{1}{3}$	300	400	.....	.....	.....	.....	.....
	5	7	$10\frac{1}{2}$	5	5	to 325	$2\frac{1}{3}$	275	642	.....	.....	.....	.....	.....
	6	9	$10\frac{1}{2}$	6	6	.....	$4\frac{1}{2}$	200	900	.....	.....	.....	.....	.....
	7	7	12	8	8	.....	7	..	...	.....	.....	.....	.....	.....
	10	8	$14\frac{1}{8}$	10	10	.....	11	.....	.....	.....	.....	.....	.....	.....
	14	12	$14\frac{1}{8}$	12	12	.....	16	.....	.....	.....	.....	.....	.....	.....
No. 2	$2\frac{3}{4}$	$3\frac{1}{8}$	$2\frac{1}{2}$	$2\frac{1}{2}$	550	$\frac{2}{10}$	550	110	.....	.....	.....	.....	.....	.....
Co.	$2\frac{1}{2}$	$3\frac{1}{2}$	5	$3\frac{1}{4}$	500	$\frac{1}{2}$	500	250	.....	.....	.....	.....	.....	.....
a Falls,	3	$4\frac{3}{8}$	6	4	400	$\frac{1}{10}$	400	333	.....	.....	.....	.....	.....	.....
N. Y.	4	$6\frac{1}{4}$	6	$4\frac{1}{2}$	350	$1\frac{1}{4}$	350	437	.....	.....	.....	.....	.....	.....
Rotary."	5	$6\frac{1}{8}$	$7\frac{1}{2}$	6	5	300	2	300	600	.....	.....	.....	.....	.....
	6	$9\frac{1}{4}$	$9\frac{1}{2}$	8	8	225	$5\frac{1}{2}$	225	1237	.....	.....	.....	.....	.....
	7	$9\frac{1}{4}$	$10\frac{1}{4}$	9	9	200	$7\frac{1}{3}$	200	1466	.....	.....	.....	.....	.....
hrey	No. 1	6	$6\frac{1}{2}$	.....	.....	300	1	300	300	.....	.....	.....	.....	.....
chine	2	6	$8\frac{1}{2}$	.....	.....	300	$1\frac{1}{3}$	300	400	.....	.....	.....	.....	.....
Co.	3	8	$8\frac{1}{2}$	.....	.....	300	$1\frac{2}{3}$	300	500	.....	.....	.....	.....	.....
, N. H.	4	8	$10\frac{1}{2}$	.....	.....	250	$2\frac{4}{10}$	250	600	.....	.....	.....	.....	.....
	5	10	$10\frac{1}{2}$	.....	.....	250	$3\frac{3}{10}$	250	800	.....	.....	.....	.....	.....
No. 2	.....	.....	$2\frac{1}{2}$	2	175 to 200	$\frac{1}{2}$	.....	.....	.....	.....	.....	.....	.....	.....
Co.	3	.....	3	$2\frac{1}{2}$	150 to 175	1	.....	.....	.....	.....	.....	.....	.....	.....
a Falls,	4	.....	5	4	125 to 150	$1\frac{2}{3}$	.....	.....	.....	.....	.....	.....	.....	.....
V. Y.	5	.....	6	5	100 to 125	$2\frac{1}{2}$	.....	.....	.....	.....	.....	.....	.....	.....

the necessity for testing, once a year, the maximum number of good fire-streams that pump can deliver. Generally speaking, *three-fourths of alloyed cast-iron* is as much as can be got out of rotary pumps at 80 to 100 lbs. pressure. Columns headed "Width of Face of Bucket" and "Distance between Centres of Bucket Shafts" are added for convenience of Inspectors in identifying size of pump when the trade number is omitted or illegible, as is often the case.

DISCHARGE

OF

DUPLEX STEAM FIRE-PUMPS.

For a given size of water-wheel.

Diameter of Water Wheel, in Inches.	Length of Stroke, in Inches.	Displacement or Area of Piston Including Allowance for Rod, in Sq. Feet.	Discharge of Pump in U. S. Gallons per Minute, Including 10% allowance for slip, short-stroke etc.		
			Discharge for each Revolution, assuming rotation of Pump = 1 single stroke.	Discharge at 75 Revolutions per minute, or ordinary highest speed for fire.	Discharge at 10 feet per minute Piston Speed.
1/2	1	2	3	4	5
3 1/2 x 10		2.40	1.05	124	99
4 x 10		2.52	1.37	140	112
4 1/2 x 10		2.65	2.35	176	141
4 1/2 x 12		2.78	2.82	212	141
5 x 10		2.82	2.93	220	176
5 x 12		2.98	3.52	264	176
5 1/4 x 10		2.90	3.25	244	195
6 x 10		3.19	4.28	321	257
6 x 12		3.43	5.14	385	257
7 x 10		3.60	5.75	431	345
7 x 12		3.92	6.90	518	345
7 1/2 x 10		3.85	6.64	498	399
8 x 10		4.11	7.59	569	455
8 x 12		4.53	9.10	688	455
8 1/2 x 10		4.39	8.60	645	516
8 1/2 x 12		4.87	10.32	774	516
9 1/4 x 10		4.84	10.23	767	614
9 1/4 x 12		5.41	12.27	920	614
9 1/4 x 18		5.11	18.41	1381	614
10 x 10		5.33	12.00	900	720
10 x 12		6.00	14.39	1079	720
10 1/4 x 10		5.50	12.61	946	757
12 x 10		6.83	17.38	1804	1043
12 x 12		7.79	20.86	1564	1043

DISCHARGE

OF

SINGLE-CYLINDER STEAM FIRE-PUMPS.

For a given size of water-end.

Diameter of Water Piston, or Plunger.	Length of Stroke.	Displacement for each single stroke of Piston (including allow- ance for Rod).	Discharge of Pump in U. S. Gallons per Minute, Including 10% allowance for slip, short-stroke, etc.		
			Discharge for each Revolution, or complete mo- tion of Pump (= 2 single strokes).	Discharge at 100 Revolutions per minute (=200 strokes), or highest ordinary speed for fire.	Discharge at 100 feet per minute Piston Speed.
Inches.	Inches.	Gallons.	Gallons.	Galls. per min.	Galls. per min.
4 × 10		0.52	0.94	94	56
4½ × 10		0.65	1.18	118	71
5 × 10		0.82	1.47	147	88
5 × 12		0.98	1.76	176	88
6 × 12		1.43	2.57	257	128
6 × 14		1.66	3.00	300	128
7 × 12		1.92	3.45	345	173
7 × 16		2.56	4.60	460	173
8 × 12		2.53	4.55	455	228
8 × 16		3.37	6.07	607	228
8 × 18		3.79	6.83	688	228
8½ × 14		3.34	6.02	602	258
9 × 18		4.84	8.70	870	290
9 × 20		5.37	9.67	....	290
9 × 24		6.45	11.60	....	290
10 × 16		5.33	9.60	....	360
10 × 20		6.66	12.00	....	360
10 × 24		8.00	14.40	....	360
11 × 22		8.90	16.02	....	437
12 × 18		8.69	15.64	....	521
12 × 22		10.62	19.12	....	521
12 × 24		11.59	20.86	....	521
14 × 20		13.12	23.61	....	708
14 × 24		15.74	28.33	....	708

TABLE C.

This is of interest mainly in illustrating what can be done with a given hydrant pressure, according to length and kind of hose used.

Note the difference in effective height and force of jet dependent on whether 500 feet or even 250 feet of hose is used, or whether 50 feet is used as in the ordinary practice test.

Note, also, the inferiority of linen hose for use in long lines, such as are called for in connection with yard hydrants.

Thus suppose that at a given mill there is available a static pressure of 80 lbs., and that the hydrant pipes are of such ample size that pressure at hydrant will be 70 lbs. when streams are playing.

We see from table that if $1\frac{1}{8}$ -inch nozzles are used the height of the effective fire streams obtainable will be :

With	50 foot line of	$2\frac{1}{2}$ -in. linen hose	.	.	.	.	.	73 feet.
"	250 "	" " " "	"	"	"	.	.	42 "
"	500 "	" " " "	"	"	"	.	.	27 "

With	50 ft. line of best and smoothest	$2\frac{1}{2}$ -in rubber-lined hose,	81 feet.
"	250 "	" " " "	61 "
"	500 "	" " " "	46 "

Note how quickly the inferiority of 2-inch hose develops when length much exceeds 50 or 100 feet.

Thus: with	250 ft. of	$2\frac{1}{2}$ -in. linen,	effective height of stream=	56 feet.
"	250 "	" 2-in.	" " " "	20 "

Note also the effect which even $\frac{1}{8}$ -inch increase in diameter has in reducing friction loss in the hose.

Thus, with 500 feet of smoothest and best rubber-lined hose —

If diam. be exactly	$2\frac{1}{2}$ -in.,	effective height of stream will be	39 feet.
If diam. be	$\frac{1}{8}$ th-in. larger,	" " " "	46 "

THREE INCH HOSE.

It will be noted that in Table C values are given for fire hose of $2\frac{3}{4}$ inches, and 3 inches internal diameter. Very little hose of these sizes has yet got into practical use; but the writer has for some months been urging several of the leading hose-makers to introduce such sizes as matters of regular stock. I am pleased to state that the Eureka Fire Hose Co. has recently introduced this 3-inch size into two or three depart-

ments, with very encouraging results. **These larger sizes are recommended for Department use, rather than Mill use,** because in City Fire Departments very long lines of hose are more frequently used. Nevertheless, it is an advantageous size in some cases for Mill Hose kept on a reel or jumper, and designed to use in protecting out-lying buildings 500 feet away from a hydrant.

The use of coupling of $2\frac{1}{2}$ -inch bore with standard thread is temporarily recommended on this $2\frac{3}{4}$ -inch and even on the 3-inch hose, in order that the interchangeability of all hose in a department, which is of the utmost importance, be preserved. The reduction of size in the coupling from 3-inch to $2\frac{1}{2}$ -inch should not be by a square quarter-inch shoulder, but by an easy tapering curve. If the reduction of bore be thus made, the loss due the constriction of diameter at couplings once in 50 feet will not offset more than one-twentieth part of the gain due to the increased size. Ultimately, of course, a standard thread 3-inch hose coupling should be provided; and it is to be earnestly hoped that in establishing the 3-inch size, one standard thread for its coupling may be agreed on, which shall be the same throughout the whole country.

The objection to the half-inch increase in size of hose is, of course, the extra weight to handle. Experience shows that in laying the empty hose this is hardly noticeable, and it is easy to arrange to have main line on ground of the large size, and to attach next the play-pipe a length or two of $2\frac{1}{2}$ -inch lighter unjacketed hose, for use on ladders.

A moment's study of the figures in Table C, for the lines of hose 500 feet and 800 feet long, gives sufficient argument for a trial of these larger sizes; and the statement I ventured that 3-inch will, before many years, be the standard size for City Fire Departments.



TABLE C.

(From experiments of J. H. PEARSON, 1888.)

PRESSURE in lbs. per sq. in. indicated at base of plug-pipe,
HEIGHT, greatest, as good effective fire stream in moderate wind,
VOLUME in U. S. gallons per minute,

of jet obtainable with a given Hydrant
 Pressure, according to Size, Kind,
 and Length of Hose used.

TAKE NOTICE.—This "Given Hydrant Pressure" is pressure at the Hydrant, measured as shown in sketch, *while stream is flowing*.
 The fire pump pressure (or static reservoir pressure) must, meanwhile, be greater than this Hydrant pressure by an amount equal
 to friction-loss between pump and hydrant. No general statement of the magnitude of this friction-loss can be made, as it depends
 on length and size of pipe-system, and number of streams being drawn, and may be anywhere from 5 to 40 or more pounds. In a
 thoroughly first-class Mill Hydrant system, this friction-loss through main pipes and valves ought not to generally exceed 10 or 15 lbs.

Available Hydrant Pressure while Stream is Flowing →

50 ft. Ordinary 2-in. Unlined Linen Hose. (Diam. couplings 2 in., but inside diam. hose 2 1/4 in.)	{ Noz. Pressure Height for Fire (Galls. per Min.) }	24	35	47	59	19	23	28	33	37	42	47	56	15	22	29	36
		42	58	71	78	34	41	49	56	61	67	72	81	28	41	52	61
50 ft. Ordinary 2 1/2-in. Unlined Linen Hose. (Diam. couplings 2 1/2 in., but inside diam. hose 2 1/4 in.)	{ Noz. Pressure Height for Fire (Galls. per Min.) }	144	174	202	226	164	180	199	216	229	244	258	282	181	210	239	262
		51	47	63	78	28	35	41	48	55	62	69	83	24	36	47	59
50 ft. Best 2 1/2-in. Rubber-Lined Cotton Hose. Inside surface very smooth. (Diam. couplings 2 1/2 in., but inside diam. hose 2 1/4 in.)	{ Noz. Pressure Height for Fire (Galls. per Min.) }	164	202	233	261	199	222	241	259	276	303	328	359	230	282	322	359
		58	74	85	91	55	65	73	81	85	89	92	98	52	71	83	92
250 ft. Ordinary 2-in. Unlined Linen Hose. (Diam. couplings 2-in., but inside diam. hose 2 1/4 in.)	{ Noz. Pressure Height for Fire (Galls. per Min.) }	174	212	246	275	212	238	261	282	301	321	338	370	252	307	358	400
		9	14	19	23	6	8	9	11	13	14	16	19	4	6	9	11
250 ft. Ordinary 2 1/2-in. Unlined Linen Hose. (Diam. couplings 2 1/2-in., but inside diam. hose 2 1/4 in.)	{ Noz. Pressure Height for Fire (Galls. per Min.) }	17	24	33	40	13	15	17	20	23	25	29	34	9	13	17	21
		90	110	128	141	102	106	16	126	140	147	150	164	97	120	139	155
250 ft. Ordinary 2 1/2-in. Unlined Linen Hose. (Diam. couplings 2 1/2-in., but inside diam. hose 2 1/4 in.)	{ Noz. Pressure Height for Fire (Galls. per Min.) }	18	28	37	46	14	17	21	24	27	31	34	41	10	15	20	25
		32	49	60	70	25	31	38	42	47	54	58	66	19	28	37	46
250 ft. Inferior 2 1/2-in. Rubber-Lined "Mill Hose." Inside surface rough and uneven.	{ Noz. Pressure Height for Fire (Galls. per Min.) }	126	155	179	200	147	156	172	184	196	209	220	241	148	181	209	234
		20	30	39	49	15	19	22	26	30	34	37	45	11	17	22	28
		35	51	63	72	27	34	39	46	52	58	67	21	32	41	50	

500 ft. Ordinary 2½-in. Unlined Linen Hose.
(Diam. coupling 2½-in., but inside diam. hose 2½-in.)

No. Pressure Height for Fire Galls. per Min.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																		
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Min.	13	20	27	33	39	45	51	57	63	69	75	81	87	93	99	105	111	117	123	129	135	141	147	153	159	165	171	177	183	189	195	201	207	213	219	225	231	237	243	249	255	261	267	273	279	285	291	297	303	309	315	321	327	333	339	345	351	357	363	369	375	381	387	393	399	405	411	417	423	429	435	441	447	453	459	465	471	477	483	489	495	501	507	513	519	525	531	537	543	549	555	561	567	573	579	585	591	597	603	609	615	621	627	633	639	645	651	657	663	669	675	681	687	693	699	705	711	717	723	729	735	741	747	753	759	765	771	777	783	789	795	801	807	813	819	825	831	837	843	849	855	861	867	873	879	885	891	897	903	909	915	921	927	933	939	945	951	957	963	969	975	981	987	993	999	1005	1011	1017	1023	1029	1035	1041	1047	1053	1059	1065	1071	1077	1083	1089	1095	1101	1107	1113	1119	1125	1131	1137	1143	1149	1155	1161	1167	1173	1179	1185	1191	1197	1203	1209	1215	1221	1227	1233	1239	1245	1251	1257	1263	1269	1275	1281	1287	1293	1299	1305	1311	1317	1323	1329	1335	1341	1347	1353	1359	1365	1371	1377	1383	1389	1395	1401	1407	1413	1419	1425	1431	1437	1443	1449	1455	1461	1467	1473	1479	1485	1491	1497	1503	1509	1515	1521	1527	1533	1539	1545	1551	1557	1563	1569	1575	1581	1587	1593	1599	1605	1611	1617	1623	1629	1635	1641	1647	1653	1659	1665	1671	1677	1683	1689	1695	1701	1707	1713	1719	1725	1731	1737	1743	1749	1755	1761	1767	1773	1779	1785	1791	1797	1803	1809	1815	1821	1827	1833	1839	1845	1851	1857	1863	1869	1875	1881	1887	1893	1899	1905	1911	1917	1923	1929	1935	1941	1947	1953	1959	1965	1971	1977	1983	1989	1995	2001	2007	2013	2019	2025	2031	2037	2043	2049	2055	2061	2067	2073	2079	2085	2091	2097	2103	2109	2115	2121	2127	2133	2139	2145	2151	2157	2163	2169	2175	2181	2187	2193	2199	2205	2211	2217	2223	2229	2235	2241	2247	2253	2259	2265	2271	2277	2283	2289	2295	2301	2307	2313	2319	2325	2331	2337	2343	2349	2355	2361	2367	2373	2379	2385	2391	2397	2403	2409	2415	2421	2427	2433	2439	2445	2451	2457	2463	2469	2475	2481	2487	2493	2499	2505	2511	2517	2523	2529	2535	2541	2547	2553	2559	2565	2571	2577	2583	2589	2595	2601	2607	2613	2619	2625	2631	2637	2643	2649	2655	2661	2667	2673	2679	2685	2691	2697	2703	2709	2715	2721	2727	2733	2739	2745	2751	2757	2763	2769	2775	2781	2787	2793	2799	2805	2811	2817	2823	2829	2835	2841	2847	2853	2859	2865	2871	2877	2883	2889	2895	2901	2907	2913	2919	2925	2931	2937	2943	2949	2955	2961	2967	2973	2979	2985	2991	2997	3003	3009	3015	3021	3027	3033	3039	3045	3051	3057	3063	3069	3075	3081	3087	3093	3099	3105	3111	3117	3123	3129	3135	3141	3147	3153	3159	3165	3171	3177	3183	3189	3195	3201	3207	3213	3219	3225	3231	3237	3243	3249	3255	3261	3267	3273	3279	3285	3291	3297	3303	3309	3315	3321	3327	3333	3339	3345	3351	3357	3363	3369	3375	3381	3387	3393	3399	3405	3411	3417	3423	3429	3435	3441	3447	3453	3459	3465	3471	3477	3483	3489	3495	3501	3507	3513	3519	3525	3531	3537	3543	3549	3555	3561	3567	3573	3579	3585	3591	3597	3603	3609	3615	3621	3627	3633	3639	3645	3651	3657	3663	3669	3675	3681	3687	3693	3699	3705	3711	3717	3723	3729	3735	3741	3747	3753	3759	3765	3771	3777	3783	3789	3795	3801	3807	3813	3819	3825	3831	3837	3843	3849	3855	3861	3867	3873	3879	3885	3891	3897	3903	3909	3915	3921	3927	3933	3939	3945	3951	3957	3963	3969	3975	3981	3987	3993	3999	4005	4011	4017	4023	4029	4035	4041	4047	4053	4059	4065	4071	4077	4083	4089	4095	4101	4107	4113	4119	4125	4131	4137	4143	4149	4155	4161	4167	4173	4179	4185	4191	4197	4203	4209	4215	4221	4227	4233	4239	4245	4251	4257	4263	4269	4275	4281	4287	4293	4299	4305	4311	4317	4323	4329	4335	4341	4347	4353	4359	4365	4371	4377	4383	4389	4395	4401	4407	4413	4419	4425	4431	4437	4443	4449	4455	4461	4467	4473	4479	4485	4491	4497	4503	4509	4515	4521	4527	4533	4539	4545	4551	4557	4563	4569	4575	4581	4587	4593	4599	4605	4611	4617	4623	4629	4635	4641	4647	4653	4659	4665	4671	4677	4683	4689	4695	4701	4707	4713	4719	4725	4731	4737	4743	4749	4755	4761	4767	4773	4779	4785	4791	4797	4803	4809	4815	4821	4827	4833	4839	4845	4851	4857	4863	4869	4875	4881	4887	4893	4899	4905	4911	4917	4923	4929	4935	4941	4947	4953	4959	4965	4971	4977	4983	4989	4995	5001	5007	5013	5019	5025	5031	5037	5043	5049	5055	5061	5067	5073	5079	5085	5091	5097	5103	5109	5115	5121	5127	5133	5139	5145	5151	5157	5163	5169	5175	5181	5187	5193	5199	5205	5211	5217	5223	5229	5235	5241	5247	5253	5259	5265	5271	5277	5283	5289	5295	5301	5307	5313	5319	5325	5331	5337	5343	5349	5355	5361	5367	5373	5379	5385	5391	5397	5403	5409	5415	5421	5427	5433	5439	5445	5451	5457	5463	5469	5475	5481	5487	5493	5499	5505	5511	5517	5523	5529	5535	5541	5547	5553	5559	5565	5571	5577	5583	5589	5595	5601	5607	5613	5619	5625	5631	5637	5643	5649	5655	5661	5667	5673	5679	5685	5691	5697	5703	5709	5715	5721	5727	5733	5739	5745	5751	5757	5763	5769	5775	5781	5787	5793	5799	5805	5811	5817	5823	5829	5835	5841	5847	5853	5859	5865	5871	5877	5883	5889	5895	5901	5907	5913	5919	5925	5931	5937	5943	5949	5955	5961	5967	5973	5979	5985	5991	5997	6003	6009	6015	6021	6027	6033	6039	6045	6051	6057	6063	6069	6075	6081	6087	6093	6099	6105	6111	6117	6123	6129	6135	6141	6147	6153	6159	6165	6171	6177	6183	6189	6195	6201	6207	6213	6219	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THE BEST KIND OF FIRE HOSE.

We are often asked to name the best kind of fire hose for the protection of mills. The needs are somewhat different from those of city fire departments.

We consider that **for attachment to standpipes in stair towers or inside the mill a thoroughly good unlined linen hose is the best**, providing the location is fairly dry, and for small hose inside the rooms *good* unlined linen is the best.

It is the best by reason of its superior lightness, compactness, and convenience for quick use by but a single man, and because there is little or no chance of its becoming stuck together by the ordinary heat of the rooms; moreover such inside hose need never be used except in case of actual fire; and linen hose, if kept dry, will retain its good quality unimpaired for many years.

For outside use, or for connection to yard hydrants, rubber-lined cotton hose is very much the best kind.

1st. Because it will not become cut and injured by chafing when lying over sharp corners or sharp gravel, nearly so easily as linen does when subject to the slight vibration due pulsations of fire pump.

2d. There is very much less loss of pressure by friction in well made rubber-lined hose than in linen (see page 6), and this makes a serious difference in jet where length is more than 200 feet.

3d. **Rubber-lined hose is best for use in the fortnightly or monthly pump trials;** for whereas linen hose is injured more or less each time it is wet, the durability of rubber-lined hose is improved, if anything, by occasionally running a stream of water through it, providing it is well dried afterward.

For inside hose in Dye Works, Print Works, or factories where air is very damp, rubber-lined cotton hose will generally prove more durable and satisfactory than linen hose.

Linen possesses the property of absorbing moisture from the air to a greater extent than is generally appreciated. Thus, in course of our investigations, the following experiment was made: Four representative samples of linen hose were carefully dried in gentle heat and then weighed. After exposing them to the air during three days of ordinary weather, the weight increased on an average $2\frac{8}{10}$ per cent. Then after being dried they were exposed to the outside air, but under shelter, during twenty-four hours of rainy weather, and on weighing again were found to have absorbed $4\frac{8}{10}$ per cent. of water, or at the rate of 1 pint of water to 100 feet of hose. This absorption of moisture, though perhaps no greater than possessed by many other fibrous materials, indicates that **linen hose ought to be stored or hung only in well ventilated**

places. Linen hose hung in closed boxes or small closets in stairways of some cotton mills where air is kept very damp, may become mildewed and worthless after a very few years. In extreme cases, a light-weight solid rubber hose may prove best suited to withstand wetness or occasional spattering by corrosive chemicals.

THE BEST SIZE OF HOSE.

For yard use, nothing smaller than 2 1-2-inch diameter should be used.

The loss of pressure is three times as great in 2-inch hose as in 2 1-2-inch, and the loss of pressure in 2¼-inch hose is 70 per cent. greater than in 2½-inch. Where a line of only 50 feet in length is used, the effect of this hose friction may perhaps not amount to much, but for longer lines is serious. (See page 44 and Table C).

Mills using 2¼-inch hose (confined almost solely to parts of Lowell and Lawrence) are urged to refit all hydrants and hose with bushings (permanently pinned or soldered in place) which fit the standard 2½-inch city fire department thread, and then, whenever new hose is procured, buy full size 2½-inch hose.

For small hose used in Card rooms, Picker-rooms or elsewhere, and fed from the sprinkler pipes or otherwise, 1¼-inch is favorite size; this should have smooth nozzle of about 7/8-inch diameter or ¾-inch diameter without any stop-cock in nozzle. This will discharge about the same quantity of water as one sprinkler head; and small hose of this size, but not larger, may be connected directly to the pipes of the sprinkler system.

The Best Kind of Rubber-Lined Hose for Mill Fire Protection.

There are ten or more makers of rubber-lined cotton hose in the U. S., and each one stoutly maintains that his goods are greatly superior to those of all competitors.

The writer has formed his own opinion of the merits of various kinds slowly and with much care, and presents the following as his **individual opinions, subject to revision as new facts appear.**

"KNIT HOSE," SO CALLED, VERSUS "WOVEN HOSE."

The writer believes that either of these two methods of arranging the threads in the cotton fabric is good enough for most practical purposes, but considers that the woven fabric is on the whole slightly superior. It withstands abrasion a little better. The knit hose is however rather more pliable and elongates only about half or two-thirds as much as the woven fabric.

The talk of knit-hose salesmen, that woven hose contracts so much on shutting off pressure as to sometimes pull over the fire-ladders, is mainly pure nonsense, and the same may be said of the talk of the "Balanced-Woven" salesmen, that ordinary woven hose will sometimes twist enough on admitting pressure to unscrew the couplings.

For mill yard use a rubber-lined hose of medium weight is preferable to the heavy jacketed hose adapted for City Fire Departments. It does not have to withstand injury from horses' hoofs and wagon wheels, is lighter to handle, less liable to mildew, and costing but two-thirds as much can be more cheerfully replaced with new when it begins to get old.

The lightest grades in the market known generally as "mill hose" are too light for the best service in mills.

From general experience it appears that the average life of rubber hose is from 5 to 10 years. It is well to mark all hose with year of purchase, with asphaltum, by figures $2\frac{1}{2}$ inches high, with lines $\frac{1}{2}$ inch broad; ordinary marking fluid wears off too quickly. **Solid rubber hose is less durable than rubber-lined hose.** Among the various samples of hose tested at Lawrence, the sample of Rubber-Lined Cotton Hose of weight best adapted for mill fire protection which made the best showing was the **O. K." Brand of the Boston Woven Hose Co.** This was the brand from which the smoothest cast shown in photograph on page 7 was taken. This hose is made with special care to meet the Factory Mutual requirements, and up to date this brand is given the preference.*

Now, that attention has been so plainly called to the importance of a smooth waterway, it is expected that certain other makers will have brands of hose specially adapted to meet the requirements of mill fire protection on the market, at an early day.

LINEN HOSE.

A large part of the linen hose now offered for sale is unworthy a place in any first-class mill.

It is made to be sold cheap, and sometimes sold with the statement that it is "good enough to hang up for the Insurance Inspectors."

Such hose can be furnished for 10 cents per foot exclusive of couplings, and is finished to look very well. To be furnished at any such price it must be woven from tow or from very low grade flax. Hose woven from the best of linen and in the best manner costs about three and one-half times the amount stated above.

* Within the past few months another and cheaper make of hose marked "O. K." has been presented to the attention of parties enquiring for "O. K. Hose." Samples of this which were shown the writer were a very light weight of knit hose, and of a grade below that which he recommends. Therefore the "O. K. Hose of the Boston Woven Hose Co." is particularly specified.

Beware of "Orphan Brands" of hose, or hose on which the maker does not place his name, but only marks it "Trade Linen," "Extra," etc., etc.

During the past winter the writer has made careful tests of about 30 different specimens of linen fire hose, including hose from each American manufacturer, and several imported samples.

Among the various samples of linen hose tested, the **Rob Roy hose**, made by McGregor & Co., of Dundee, Scotland, has up to date proved tightest, and at date this, so far as we are informed, is the only brand sold under a specific guaranty as to tightness and proper quality of stock. Therefore at the present writing we give this brand the preference. But in case it should be found that this Rob Roy brand, or the O. K. brand mentioned above, are not maintained strictly up to grade, this approval will of course be withdrawn.

The Eureka Hose Co., of New York, has been giving much attention to this matter, and has presented some very good samples. Their process of circular weaving has been proved by our experiments to give much additional strength; and we are led to expect that they will soon have on the market a thoroughly satisfactory hose. It is also expected that Mr. G. A. Eberle and Ross, Turner & Co. will soon be ready to furnish hose in accordance with the specifications below.

In testing the various samples of hose, as mentioned above, the defect most often developed in linen hose was excessive leakage.

Whether linen hose contains the seeds of decay, due to its yarn not having been properly cleansed, takes time to determine, and must rest mainly upon the guarantee of an honorable and responsible manufacturer.

To secure the use of a suitable quality of linen hose in our mills, the only course appeared to be to **urge mills to buy their hose direct from the manufacturer**, and for us to select several reliable makers, and induce them to manufacture hose for our members in accordance with certain specifications.

The following were therefore submitted; and at date the Boston Woven Hose Co. furnishes a brand of hose, the Rob Roy, mentioned above, which is guaranteed to meet them:—

SPECIFICATIONS FOR LINEN FIRE-HOSE.

TRADE-MARK.

Item 1. Each piece of hose to have a **distinct and conspicuous trade-mark**, consisting of colored warp threads woven into the fabric of the hose.

Item 2. The **name of the manufacturer**, together with the **year of manufacture**, to be stencilled upon each and every piece of this hose once in each 15 feet of length, with black letters at least 1½ inches in height.

TESTING.

Item 3. Each web of hose to be **numbered serially** as it comes from the

loom, and this number to be also stencilled on each 50-foot section of the hose; and each of these hose manufacturers to agree to maintain an apparatus for testing the bursting strength and amount of sweating of hose under a pressure of 75 pounds, and to agree to test a sample at least three feet in length, taken from each web as it comes from the loom; this three-foot sample to be cut preferably not from the end, but taken from some intermediate point when cutting the web up into 50-foot sections. A record is to be kept of these tests.

BURSTING STRENGTH.

Item 4. The maker to guarantee: First, that hose bearing his name and trade-mark shall not, on delivery, burst at a water pressure less than **400 pounds per square inch**; hose to be wet under pressure for from 10 to 20 minutes before bursting.

LEAKAGE.

Second, that after having been wet under a pump or hydrant pressure of 75 pounds and thoroughly dried, that then, **on being subjected a second time to a water pressure of 75 pounds, the total leakage during the first minute shall not exceed one-sixth of a gallon per foot in length**, and that upon this second trial, after the hose has been wet for five minutes, **the total leakage during the next five minutes shall not exceed .01 gallon per foot in length**; the water-pressure meanwhile being 75 lbs. per square inch.

QUALITY OF FLAX AND CLEANSING OF FIBRE.

Item 5. The manufacturer of the hose to guarantee that the yarn from which the hose is woven has been procured from a first-class and responsible manufacturer, whose name is given under a written guaranty that it was **spun from first quality line**, and that it has been **cleansed by boiling in soda-ash solution** of a strength obtained by using a weight of soda equal to at least one-tenth of the weight of the yarn, for at least three hours; then properly washed in clean water, and then **boiled again**, in a similar alkaline solution, for two hours more.

It may in future be found advisable to slightly modify the above figures limiting the sweating and alkali boiling, and to add an item requiring antiseptic treatment.

A competition in excellence, rather than in price, may result in attaining, in regular practice, a quality considerably in advance of that called for in the foregoing specifications.

RUBBER-LINED LINEN HOSE.

This is not recommended for mill use. Although it is often claimed that the sulphur in the rubber injures the strength of the linen, the writer has not seen proof of this which can be regarded as conclusive, and the reason for not recommending it is that **for lining with rubber, linen presents no advantage to compensate for its increased cost.**

It is practicable to make good linen hose tight enough without a rubber lining.

The advantage of flax over cotton for fire hose comes from its fibres swelling when wet, and thus making hose tight; with a rubber-lined

hose, the necessity for this swelling of fibres is removed. **The main advantage of linen hose over rubber-lined hose** for inside protection comes from the fact that **unlined linen hose could probably be stored in a dry, well ventilated apartment, for twenty years or more,** without much deterioration. Rubber fabric, on the other hand, will, five times out of ten, lose its pliability or strength inside of ten years, and sometimes inside of five years, and therefore **by adding the the rubber lining we shorten the life of the linen hose.**

There may be some few situations where even slight leakage would cause great damage, for which rubber-lined linen hose may be best adapted as furnishing a perfectly tight hose of very light weight; but it should **receive careful examination after it gets five years old,** and be thrown away as soon as showing signs of failure.

LEATHER HOSE.

At the present day this is not considered nearly so good as rubber-lined cotton, for the protection of a mill. It costs a little more than twice as much as the grade of hose recommended above, and interest on the capital invested in the leather hose would therefore renew this kind of rubber-lined hose, or the best of linen hose, once in every dozen years. Leather hose is stiff and unwieldy, and apt to be leaky; but if honestly made from the best of stock, and properly cared for, it will in the fire department of a country village probably endure more years of service than any other kind of hose.

We find some of this old leather hose still in commission at some of our older mills. As illustrating that it is liable to be worthless, we may cite an experience of our former associate, Mr. Wm. F. Sherman, who, on leaving us to take the management of the Atlantic Mills, found some leather hose on hand which looked bright and serviceable. Guided by previous experience, Mr. Sherman connected it all in one long line to a hydrant, and found that seven out of the ten lengths burst under the city reservoir pressure of 70 lbs.

Any leather hose now remaining in use is old enough to justify a most rigid inspection.

HOSE COUPLINGS.

Some dealers in fire apparatus, when a cheap article is called for, make use of the old-fashioned shank couplings, and wire them on. These not only **obstruct waterway unnecessarily,** but are liable to **blow off at a critical moment,** and they ought not to be used.

Nothing but a first-class expanded-ring coupling should be used, — and these should be put on solely by conscientious workmen experienced in this particular line of work, and having the best of tools; otherwise they may blow off under fire pressure. This is another reason why it is safest to order fire hose all coupled direct from the factory, rather than through a supply house.

Nearly all hose manufacturers furnish couplings which are entirely satisfactory.

Should any one desire an extra strong coupling, it may be remarked that the strongest coupling thus far tested appeared to be the "Morse Coupling" (not to be confused with the lighter "Ne Plus" of the same maker, which, however, appears to be a good average coupling), made and applied by A. J. Morse & Son, 140 Congress Street, Boston.

In the course of the linen hose tests, some fifty of these were tested up to pressures of 400 to 700 lbs. per square inch, and none blew off or leaked; and in the hose tests made by this office about eight years ago, some couplings of this kind were tested on $2\frac{1}{2}$ -inch hose to 1,000 lbs. pressure per square inch, without showing any signs of failure.

SPANNERS.—The writer is prompted to add a word about spanners, from having seen so much fumbling by mill firemen in coupling up hose with the ordinary old-style spanner, which is likely to be applied in the wrong direction.

The Taber Spanner is recommended. This is sold by nearly all dealers, and cannot be put on wrong. Its cost—list \$6.00 per dozen—does not very materially exceed that of the ordinary spanner.

There are also several other good patent spanners in the market.

The foregoing has been prepared in its present form in order to have the matter in shape for convenient reference during the pump tests of 1889.

The writer hopes to next winter find time to add some more notes on pumps, some tables on friction loss in pipes, notes on the laying out of hydrant systems, and also to bring the hose question up to that date, as we expect that there will then be other names to add to the list of makers of satisfactory goods.

There are also several devices in process of construction, such as valve-opening indicators, nozzle rests, and an improved Siamese play-pipe; of which it is hoped that the merit may by that time have been tested by practical experience.

This whole pamphlet may perhaps then, if the conference so elects, be published in the form of a special report.

The writer mentions this lest some of the members of the corps may think that he has been too eager to tell them facts which they already know.

Respectfully submitted.

JOHN R. FREEMAN,

Hydraulic Engineer and Inspector.



7.3.3 = $\frac{1}{2}$ CONVERTING PRESSURE IN IN
HEAT OF WATER.

PROSEDURE DI FORMULE PER LA SOLUZIONE DELL'ESERCIZIO

[illegible]

the used in computing above table: One cubic foot of pure water, at a
of 60 degrees Fahr., weighs 62.366 pounds avoirdupois per Rosse
pounds. See Hamilton Smith, Jr.'s, Hydraulics, ed. 1886, p. 1
/ lb. = 4.545454 fl. oz.

**TABLE FOR CONVERTING PRESSURE GIVEN IN POUNDS
PER SQUARE INCH,
Into Feet Head of Water.**

	Lbs. per Sq. in.	Feet Head.	Lbs. per Sq. in.	Lbs. per Sq. in.	Feet Head.	Lbs. per Sq. in.	Feet Head.	Lbs. per Sq. in.	Feet Head.	Lbs. per Sq. in.	Feet Head.
1	104.38	281	121.70	1	2.31	41	94.67	81	187.02	121	279.38
2	104.81	282	122.13	2	4.62	42	96.98	82	189.33	122	281.69
3	105.24	283	122.56	3	6.93	43	99.28	83	191.64	123	284.00
4	105.68	284	123.00	4	9.24	44	101.59	84	193.95	124	286.31
5	106.11	285	123.43	5	11.54	45	103.90	85	196.26	125	288.62
6	106.54	286	123.86	6	13.85	46	106.21	86	198.57	126	290.93
7	106.97	287	124.30	7	16.16	47	108.52	87	200.88	127	293.24
8	107.41	288	124.73	8	18.47	48	110.83	88	203.19	128	295.55
9	107.84	289	125.16	9	20.78	49	113.14	89	205.50	129	297.85
0	108.27	290	125.60	10	23.09	50	115.45	90	207.81	130	300.16
1	108.71	291	126.03	11	25.40	51	117.76	91	210.11	131	302.47
2	109.14	292	126.46	12	27.71	52	120.07	92	212.42	132	304.78
3	109.57	293	126.90	13	30.02	53	122.37	93	214.73	133	307.09
4	110.01	294	127.33	14	32.33	54	124.68	94	217.04	134	309.40
5	110.44	295	127.76	15	34.63	55	126.99	95	219.35	135	311.71
6	110.87	296	128.19	16	36.94	56	129.30	96	221.66	136	314.02
7	111.30	297	128.63	17	39.25	57	131.61	97	223.97	137	316.33
8	111.74	298	129.06	18	41.56	58	133.92	98	226.28	138	318.64
9	112.17	299	129.49	19	43.87	59	136.23	99	228.59	139	320.94
0	112.60	300	129.93	20	46.18	60	138.54	100	230.90	140	323.25
1	113.04	301	130.36	21	48.49	61	140.85	101	233.20	150	346.34
2	113.47	302	130.79	22	50.80	62	143.15	102	235.51	160	369.43
3	113.90	303	131.23	23	53.11	63	145.46	103	237.82	170	392.52
4	114.34	304	131.66	24	55.41	64	147.77	104	240.13	180	415.61
5	114.77	305	132.09	25	57.72	65	150.08	105	242.44	190	438.70
6	115.20	306	132.53	26	60.03	66	152.39	106	244.75	200	461.79
7	115.64	307	132.96	27	62.34	67	154.70	107	247.06	225	519.51
8	116.07	308	133.39	28	64.65	68	157.01	108	249.37	250	577.24
9	116.50	309	133.82	29	66.96	69	159.32	109	251.68	275	634.96
0	116.93	310	134.26	30	69.27	70	161.63	110	253.98	300	692.69
1	117.37	325	140.75	31	71.58	71	163.94	111	256.29	325	750.41
2	117.80	350	151.58	32	73.89	72	166.24	112	258.60	350	808.13
3	118.23	375	162.41	33	76.20	73	168.55	113	260.91	375	865.86
4	118.67	400	173.24	34	78.50	74	170.86	114	263.22	400	923.58
5	119.10	500	216.55	35	80.81	75	173.17	115	265.53	500	1154.48
6	119.53	600	259.85	36	83.12	76	175.49	116	267.84	600	1385.37
7	119.97	700	303.16	37	85.43	77	177.79	117	270.15	700	1616.27
8	120.40	800	346.47	38	87.74	78	180.10	118	272.46	800	1847.16
9	120.83	900	389.78	39	90.05	79	182.41	119	274.77	900	2078.06
0	121.27	1000	433.09	40	92.36	80	184.72	120	277.07	1000	2308.95

difference in specific gravity between ordinary river water and distilled water is practically inappreciable. In other words, a head of 1000 feet of ordinary New England river-water would give a pressure not more than .02 lb. greater than for a column of distilled water 1000 feet high.

CAPACITY OF PIPE

In United States Ga

Capacity of Cylindrical Tanks and Cisterns.

Diam.	2 ft.	3 ft.	4 ft.	5 ft.	6 ft.	7 ft.	8 ft.	9 ft.	12 ft.	Diam.
2	23.5		105	121	155	188	212	282		
3	23.5		121	137	171	204	228	307		
4	23.5		137	153	187	220	244	323		
5	23.5		153	169	203	236	260	339		
6	23.5		169	185	219	252	276	355		
7	23.5		185	201	235	268	292	371		
8	23.5		201	217	251	284	308	387		
9	23.5		217	233	267	300	324	403		
10	23.5		233	249	283	316	340	419		
11	23.5		249	265	299	332	356	435		
12	23.5		265	281	315	348	372	451		
13	23.5		281	297	331	364	388	467		
14	23.5		297	313	347	380	404	483		
15	23.5		313	329	363	396	420	500		
16	23.5		329	345	379	412	436	515		
17	23.5		345	361	395	428	452	531		
18	23.5		361	377	411	444	468	547		
19	23.5		377	393	427	460	484	563		
20	23.5		393	409	443	476	500	580		
21	23.5		409	425	459	492	516	595		
22	23.5		425	441	475	508	532	611		
23	23.5		441	457	491	524	548	627		
24	23.5		457	473	507	540	564	643		
25	23.5		473	489	523	556	580	660		
26	23.5		489	505	539	572	596	675		
27	23.5		505	521	555	588	612	691		
28	23.5		521	537	571	604	628	707		
29	23.5		537	553	587	620	644	723		
30	23.5		553	569	603	636	660	739		
31	23.5		569	585	619	652	676	755		
32	23.5		585	601	635	668	692	771		
33	23.5		601	617	651	684	708	787		
34	23.5		617	633	667	700	724	803		
35	23.5		633	649	683	716	740	819		
36	23.5		649	665	699	732	756	835		
37	23.5		665	681	715	748	772	851		
38	23.5		681	697	731	764	788	867		
39	23.5		697	713	747	780	804	883		
40	23.5		713	729	763	796	820	900		
41	23.5		729	745	779	812	836	915		
42	23.5		745	761	795	828	852	931		
43	23.5		761	777	811	844	868	947		
44	23.5		777	793	827	860	884	963		
45	23.5		793	809	843	876	900	979		
46	23.5		809	825	859	892	916	995		
47	23.5		825	841	875	908	932	1011		
48	23.5		841	857	891	924	948	1027		
49	23.5		857	873	907	940	964	1043		
50	23.5		873	889	923	956	980	1059		
51	23.5		889	905	939	972	996	1075		
52	23.5		905	921	955	988	1012	1091		
53	23.5		921	937	971	1004	1028	1107		
54	23.5		937	953	987	1020	1044	1123		
55	23.5		953	969	1003	1036	1060	1140		
56	23.5		969	985	1019	1052	1076	1156		
57	23.5		985	1001	1035	1068	1092	1171		
58	23.5		1001	1017	1051	1084	1108	1187		
59	23.5		1017	1033	1067	1100	1124	1203		
60	23.5		1033	1049	1083	1116	1140	1219		
61	23.5		1049	1065	1099	1132	1156	1235		
62	23.5		1065	1081	1115	1148	1172	1251		
63	23.5		1081	1097	1131	1164	1188	1267		
64	23.5		1097	1113	1147	1180	1204	1283		
65	23.5		1113	1129	1163	1196	1220	1300		
66	23.5		1129	1145	1179	1212	1236	1315		
67	23.5		1145	1161	1195	1228	1252	1331		
68	23.5		1161	1177	1211	1244	1268	1347		
69	23.5		1177	1193	1227	1260	1284	1363		
70	23.5		1193	1209	1243	1276	1300	1379		
71	23.5		1209	1225	1259	1292	1316	1395		
72	23.5		1225	1241	1275	1308	1332	1411		
73	23.5		1241	1257	1291	1324	1348	1427		
74	23.5		1257	1273	1307	1340	1364	1443		
75	23.5		1273	1289	1323	1356	1380	1459		
76	23.5		1289	1305	1339	1372	1396	1475		
77	23.5		1305	1321	1355	1388	1412	1491		
78	23.5		1321	1337	1371	1404	1428	1507		
79	23.5		1337	1353	1387	1420	1444	1523		
80	23.5		1353	1369	1403	1436	1460	1539		
81	23.5		1369	1385	1419	1452	1476	1555		
82	23.5		1385	1401	1435	1468	1492	1571		
83	23.5		1401	1417	1451	1484	1508	1587		
84	23.5		1417	1433	1467	1500	1524	1603		
85	23.5		1433	1449	1483	1516	1540	1619		
86	23.5		1449	1465	1499	1532	1556	1635		
87	23.5		1465	1481	1515	1548	1572	1651		
88	23.5		1481	1497	1531	1564	1588	1667		
89	23.5		1497	1513	1547	1580	1604	1683		
90	23.5		1513	1529	1563	1596	1620	1700		
91	23.5		1529	1545	1579	1612	1636	1716		
92	23.5		1545	1561	1595	1628	1652	1732		
93	23.5		1561	1577	1611	1644	1668	1748		
94	23.5		1577	1593	1627	1660	1684	1764		
95	23.5		1593	1609	1643	1676	1700	1780		
96	23.5		1609	1625	1659	1692	1716	1795		
97	23.5		1625	1641	1675	1708	1732	1811		
98	23.5		1641	1657	1691	1724	1748	1827		
99	23.5		1657	1673	1707	1740	1764	1843		
100	23.5		1673	1689	1723	1756	1780	1859		

Gallons contained in 100 feet in length of Pipe.

Diam.	Galls.	Diam.	Galls.	Diam.	Galls.	Diam.	Galls.	Diam.	Galls.
2 1/4 in.	2.30	2 in.	16.32	4 in.	65.3	8 in.	261.1	20 in.	1044.5
1 in.	4.08	2 1/2 in.	25.50	5 in.	102.0	10 in.	408.1	24 in.	1602.0
1 1/4 in.	6.38	3 in.	36.73	6 in.	146.9	12 in.	587.6	30 in.	2356.0
1 1/2 in.	9.18	3 1/2 in.	49.98	7 in.	199.9	16 in.	1044.5	36 in.	2800.0

TANKS, AND CISTERNS.

231 cubic inches.)

Capacity of Cylindrical Tanks and Cisterns. — Continued.

am. In.	Depth 1 ft.	Depth 4 ft.	Depth 5 ft.	Depth 6 ft.	Depth 7 ft.	Depth 8 ft.	Depth 9 ft.	Depth 12 ft.	Depth 15 ft.
1....	587.5	2350	2938	3525	4113	4700	5288	7050	8813
3	617.3	2469	3086	3704	4321	4938	5555	7407	9259
6	647.7	2591	3239	3886	4534	5182	5830	7773	9716
9	679.0	2716	3395	4074	4753	5432	6111	8147	10184
1....	710.9	2844	3555	4265	4976	5687	6398	8531	10664
3	743.6	2974	3718	4462	5205	5949	6692	8923	11154
6	777.0	3108	3885	4662	5439	6216	6993	9324	11655
9	811.1	3245	4055	4867	5678	6489	7300	9734	12167
2....	846.0	3384	4230	5076	5922	6768	7614	10152	12691
6	918.0	3672	4590	5508	6426	7344	8262	11016	13770
3....	992.9	3972	4965	5957	6950	7943	8936	11915	14894
6	1070.8	4283	5354	6425	7495	8566	9637	12849	16061
4....	1151.5	4606	5758	6909	8061	9212	10364	13819	17273
6	1235.3	4941	6176	7412	8647	9882	11117	14823	18529
5....	1321.9	5288	6610	7932	9253	10575	11897	15863	19829
8....	1504.1	6016	7520	9024	10528	12032	13537	18049	22561
7....	1697.9	6792	8490	10188	11886	13583	15281	20375	25469
8....	1903.6	7614	9518	11421	13325	15228	17132	22843	28553
9....	2120.9	8484	10605	12726	14847	16968	19089	25451	31814
10....	2350.1	9400	11750	14100	16451	18801	21151	28201	35251
2 ...	2843.6	11374	14218	17062	19905	22749	25592	34123	42654
4....	3384.1	13536	16921	20305	23689	27073	30457	40609	50762
6....	3971.6	15887	19858	23830	27801	31773	35745	47660	59575
8... .	4606.2	18425	23031	27637	32243	36849	41455	55274	69992
10....	5287.7	21151	26438	31726	37014	42301	47589	63452	79315
2....	6016.2	24065	30081	36097	42113	48130	54146	72194	90243
5....	7197.1	28788	35986	43183	50380	57577	64774	86365	107957
10....	9400.3	37601	47002	56402	65802	75202	84603	112804	141005
5....	11897.3	47589	59486	71384	83281	95178	107075	142767	178459
10....	14688.0	58752	73440	88128	102816	117504	132192	176256	220319
10....	21150.7	84603	105753	126904	148055	169205	190356	253808	317260
10....	28788.4	115154	143942	172730	201519	230307	259096	345461	431826

cubic foot contains $7\frac{1}{2}$ gallons nearly, or 7.48052 gallons exactly.

cubic foot of pure water, at a temperature of 60 degrees Fahrenheit, weighs 62.366 lbs.

U.S. gallon of pure water, at a temperature of 60 degrees Fahrenheit, weighs 8.331 lbs.

0.07 gallons of water weigh one ton of 2000 lbs.

100 gallons of water weigh 4.165 tons, or 4 tons approximately.

The amount of water required to fill an ordinary automatic sprinkler system is about 1 gallon per sprinkler. This includes riser and all distribution pipes within the mill, but does not include ground mains from pump or city supply to base of riser. This figure (1 gall. per head) applies specially to systems piped from centre, with 75 to 115 heads on each floor. If system of 115 heads is fed from end instead of centre, contents will be about $1\frac{1}{4}$ gallons per head. For large systems, with 6-inch riser and about 250 heads per floor, contents, if riser is in centre, will be about $1\frac{1}{4}$ gallons per head, and if riser is at one end, will be $1\frac{1}{2}$ gallons per head.

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